ELECTRICITY

AS A

FIRE HAZARD.

PAPER BY

W. J. JENKS,

READ BEFORE THE

WORLDS' FIRE INSURANCE CONGRESS, HELD UNDER THE AUSPICES OF THE CONGRESS AUXILIARY OF THE WORLD'S COLUMBIAN EXPOSITION, IN CHICAGO, JUNE, 1893.

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"THE ELECTRICAL ENGINEER" (NEW YORK).

July 18, 1894.

Electricity as a Fire Hazard.

Electricity has been proved to be so safe a medium for light and power distribution that electrical journals have long since ceased to reply to the aspersions that are still cast on it from time to time by those who have ulterior objects in view. But, on the other hand, there are none better able to judge of the real danger due to loose methods of construction than electrical engineers themselves. Where but an apparently insignificant "leak" may in time be aggravated into a serious fault it behooves all connected with the installation and operation of modern electrical apparatus to know exactly in what manner the danger is created and to provide the necessary means for its prevention. In the admirable paper on "Electricity as a Fire Hazard," by Mr. W. J. Jenks, there will be found a most clear and exhaustive explanation of many of the effects which have puzzled and annoyed others besides the fire underwriters. It is too much to expect that the fire records will ever be entirely free from electrical losses, but the work which the various Boards of Fire Underwriters and the National Electric Light Association have accomplished in bringing about improved methods of construction has already done so much towards increased safety that the loss from this cause is gradually but surely assuming an asymptotic character.

"THE ELECTRICAL ENGINEER" (NEW YORK).

August 29, 1894.

Electricity as a Fire Hazard.

With this issue we bring to a close the admirable paper by Mr. W. J. Jenks, on "Electricity as a Fire Hazard," which ought to be carefully studied

by every one connected with the installation of electric lighting or power plants. We cannot but believe that the losses from fire, legitimately traceable to electric currents, have been due to the ignorance rather than the negligence of those in charge of such plants, and that, if the true limitations of conductors carrying currents were better known, electrical fires would become a thing of the past. That electricity can be distributed safely is admitted even by the fire underwriters, but it took them a long time to make up their minds to the fact. While the fire underwriters may be looked upon in some quarters as enemies to electric lighting, we believe that all well-informed and right-thinking members of the electrical community are in accord with their efforts to secure proper electric installation; and, while the insurance regulations may err on the side of safety, the public, after all, benefit thereby in the long run. As Mr. Jenks shows, the apparent excessive factor of safety called for by the underwriters' rules is demanded by reason of the fact that in many cases conductors are, after a time, called upon for service far in excess of that for which they were originally designed—and this without any attempt at fraud or deception. It is too much to hope that complete immunity from electrical fires can be obtained, even under the best system of rules; but, when the early and defective installations are finally remodeled, it is safe to say that an electrical fire will be a rare occurrence. What is really now needed is that the various rules governing electrical installations should be brought to the point of harmony and uniformity. In some respects they now disagree and conflict, but there should be no trouble in making them support each other alike in letter and spirit. Such uniform rules would sound the death knell of bad work.

"THE ELECTRICAL REVIEW" (LONDON).

November 16, 1894.

Electricity as a Fire Hazard.

The "World's Fair" of last year was responsible for many congresses and social gatherings of various orders being held in the far-famed city of the West. It was only fitting, therefore, that the insurance underwriters of the States, amongst others, should assemble in congress within the precincts of the great show, and thus happily combine pleasure with business. It was also no doubt right and proper that in the midst of their festivities, like the Egyptians of old, they should be reminded of more serious matters, and, perhaps, as a shocker, nothing more suitable could have been paraded than that well-worn skeleton—the "electrical fire hazard." For, rightly or wrongly, the fire underwriter does largely attribute his heavy losses of late years in the States to the electrical fiend.

The "Electrical Engineer" of New York lately reproduced, in nine weekly installments, a paper on the above subject by Mr. W. J. Jenks, as read before the Insurance Congress, Chicago, 1893. The paper deals at some length with the effects of leakages in underground and overhead mains upon house wiring, and the dangers of various forms of "earths" and "shorts" due to such leakages. In fact, the theme is *insulation*, the author incidentally touching upon the origin of insurance rules, and quoting various authorities upon the weakness of wood casing as protection to conductors—our old friend, the gas pipe, being recommended instead. No doubt there is a very great deal to be said in favor of iron barrel piping, particularly where conductors are hidden from view and embedded in walls, but it will not recommend itself to the multitude, with whom cheapness is the first consideration. Our readers will doubtless be glad to know that the standard of wiring in the States is now said by American experts to be quite equal to the best work on this side of the water; neither, however, being perfect, and both subject to occasional breakdowns and minor casualties. Mr. Jenks, doubtless recognizing the special circumstances of the occasion, departed from the usual single-line diagrams, and illustrated his paper with highly-colored drawings, showing dynamos in perspective, conductors of gigantic proportions with their insulation laid bare, solid and substantial gas fittings, and the "earths" decidedly earthy; the whole well peppered with arrows indicating the direction the current should go when all is in order and where it is likely to go when led into temptation. The paper is well worth reading by those interested in the subject from a fire point of view; but in some respects it is decidedly disappointing, and scarcely so advanced as we should have expected from Chicago. The author, for instance, has nothing to say about the complications of the *three* and *five-wire* systems of distribution, now so much in vogue, nor of that bugbear "electrolysis," as affecting gas and water pipes.

There is on record in this country a fire produced by an electrical discharge from an iron pipe enclosing a faulty high-tension main, whereby a neighboring gas pipe was perforated as though by red-hot shot. In the opinion of experts this perforation was due to the water running down the iron pipe becoming so strongly electrified as to be repelled, or discharged, with sufficient force to penetrate the soft-metal gas pipe near. Now, a colored diagram of a bombardment of gas pipes with electrified water would have been highly effective, and a better hair raiser than mere short circuits in simple parallel, as served up by Mr. Jenks for the edification of the Chicago Congress.

[NOTE.—The "Review" erroneously assumes that the "Engineer" printed the entire paper. The portions referring to the three-wire method, on pages 36-38, were omitted in the "Engineer's" abstract.]

"THE ELECTRICAL JOURNAL" (SAN FRANCISCO).

July, 1895.

Electricity as a Fire Hazard, by W. J. JENKS. A paper read before the World's Fire Insurance Congress, Chicago, June, 1893. Paper, 73 pages. Published by the General Electric Company, presumably for gratuitous distribution.

In presenting this book to the public the donors have performed a service meriting the appreciation of all who are interested in the common weal. Ordinarily there is so much of the mysterious about electricity in the minds of the public that any successful effort in the way of enlightenment from that unfortunate condition deserves commendation. Such is a characteristic of Mr. Jenks' valuable paper, which is, in reality, a comprehensive review of the technical side of electro-insurance relations during the past sixteen years, freely elaborated with the views of the author. A reasonable inference is that the paper, being published by an electric company, is designed to further the interests of the corporation fathering it; but, despite this, the book is free from bias, and presents the various hazards of the applications in a clear, lucid way and with profuse colored drawings. It is a book for fire underwriters as well as for electrical men, and its publication cannot but remind insurance interests that their own efforts to restrict the fire hazard of electricity are no more sincere and earnest than are those of the legitimate electrical fraternity.

ELECTRICITY AS A FIRE HAZARD.

It is less than fifteen years since the attention of the fire insurance underwriters was first directed toward a class of hazards previously unknown to them, namely the dangers to property attending the use of the electric currents necessary for the supply of electric lamps and motors distributed about the premises of the owner of a mill or a business block from an isolated electric plant, or more widely scattered in the stores or dwellings of many consumers supplied from a central station.

There is a reason for this delay of the electrical fire hazard in putting in its appearance, and this reason lies at the foundation of an adequate conception of precisely in what that hazard consists.

All the older electrical systems of transmission, such as the telegraph, fire-alarm, burglar alarm, gas-lighting and telephone, obeyed in their operation the same natural laws as the even now youthful electric light and electric power systems. But the source of their electrical energy was usually the chemical battery which excited its useful force by the burning of zinc or similarly expensive material, was difficult to keep in an efficient condition and required a large investment to yield a small result in actual energy produced. It was among other things because these prior systems required for their operation but a small expenditure of power in the form of electricity that they were commercially useful, for the economical production of large quantities of electric power, so to speak, followed the later developments of apparatus for light and power transmission.

The coming of the electric arc lamp, requiring nearly a horse-power of mechanical energy for each large unit of light, and the softer incandescent or glow-lamp which only gave from 110 to 125 candles of light for each mechanical horse-power, usually in the form of 7 or 8 lamps of 16 candles each, demanded an electric current representing 1,000 horse-power for each 1,000 arc lamps required for the lighting of the streets of a city, or each 7,000 glow-lamps for stores and dwellings.

There is perhaps no more impressive example of almost irresistible power than a modern high-speed locomotive and its vestibuled limited express train flying at the rate of a mile a minute between the great cities of the United States. The total weight of such a train is from 400 to 500 tons, or from 800,000 to 1,000,000 pounds, and a speed of 75 miles per hour is sometimes attained. The energy of 400 tons moving at that speed is nearly twice as great as that of a 2,000-pound shot fired from a 100-ton Armstrong gun. But these illustrations express a power only about one-half of that

constantly required for the lighting of the art gallery at the World's Columbian Exposition by 16,000 incandescent lamps. Because under ordinary circumstances the electric current speeds along the motionless conductor without causing a quiver or vibration perceptible to our eyes or ears, we are apt to overlook the fact that its power for great usefulness and instantaneous transmission of a variety of manifestations of energy, when properly directed, is equalled by its ability to do serious mischief whenever it escapes from our control.

EXPLANATION OF ELECTRICAL PRINCIPLES.

The possibility of commercially generating electricity on such a scale was only realized when the modern dynamo-electric machine was made practical, and by its means the tremendous energy of motion derived from the power of waterfalls and steam-boilers was substituted for the feeble combustion of chemical cells. The coils of the armature of the dynamo, being forced by the resistless pressure of steam to revolve between the poles of powerful magnets in the field of magnetic force and in spite of the attraction with which that force opposes the revolution, develop and send out this marvelous agent which we call Electricity, not in transitory sparks like the discharge of the Leyden jar, not in an almost microscopic wave like the pulsations of a telegraph or telephone circuit, but in a maintained succession of powerful throbs following each other in such close intervals of time as to constitute a practically uniform flow of any volume we desire, so that we popularly speak of it, for want of a better analogy, as if it were water or gas, and moved in tangible particles from point to point. This analogy is only apparent and not real, and to make this perfectly clear we need only call to mind that in some systems the impulses are always in one direction and make up what we call a "direct" current, while in others this direction is continually reversed several hundred times a second, and is then known as "alternating." It is not necessary for the purposes of this paper that any distinction be made between these two methods of using electricity, excepting as may be hereafter specified. It may be profitable to briefly rehearse a few underlying principles which apply to all varieties of the so-called currents of electricity with which the fire insurance man is called upon to deal.

Electricity is not in itself a source of energy; it is not itself ordinarily useful or available to us as a force which directly affects our sensibilities, or which completes a useful operation. It is rather an intermediary agent, having two great features of utility:—first, it transforms or translates one manifestation of Nature's forces into another; second, it transfers energy (while in the intermediate state which we call electrical action) from point to point instantly. As an intermediary agent it is thus both a skillful magician and a swift-winged messenger. By its action, one manifestation of natural power, as for instance the motion of a waterfall, disappears, and in its stead another and more useful manifestation of heat, light or chemical action is developed, either in the same place or in a different place, as we desire. When we wish it to transmit or transfer power, we connect with the source of energy a suitable path in the form of a material which readily conducts electrical impulses, and we find the power appearing at the objective point

before we can realize that the transmission has taken place. Wherever, in the path thus provided we wish to do useful work, we place an obstruction which the electricity must overcome, and in the operation of surmounting such an obstacle a part, or practically the whole of its energy may be expended. While we cannot tell what electricity is, we can say that for the purposes of practically generating and controlling it, it has but one element, namely, a "pressure," "strain," or "tension," which in systems of electric lighting, for example, is steadily generated by the dynamo, which is the mechanism in which the electrical force first appears, and that it is as steadily expended in the "circuit" or path by which we connect the outgoing and the incoming terminals of the dynamo, and with such instantaneous effect that the moment we connect such a source of power with a conductor forming a complete circuit, the pressure has traversed the entire path and has spent its entire force, which in technical language we call "electro-motive force." At every point in this path, or, more accurately, between any two points, no matter how large or easy this path may be, we find that some fraction of this total pressure has been expended in exact proportion to the opposition it has met, or, in other words, to the resistance it has encountered. As long as the connection with the source of power is kept up, this generation and expenditure may be maintained; the instant we break the connection at any point in the complete circuit all action ceases, because the electrical pressure generated before the break occurred has been instantly used up or transformed into some other form of energy, such as heat, light, magnetism, chemical action or motion. The portion of the initial pressure which is inevitably expended between the point where it is generated and the point where it is made useful in a "translating device" is transformed into heat and disappears, thus being, so far as any useful result is concerned, lost or wasted. Hence, the loss of pressure in transmission is often called "drop" in pressure, and the energy thus lost is known as "heat waste." The translating device may be a lamp, a heater, a motor, a plating-bath or a magnet, in short any mechanism within which the energy of electricity may be translated or transformed to some other serviceable form of energy.

We can measure the electrical pressure which is generated by the action of a chemical battery or the revolution of the armature of a dynamo-electric machine, and this we do in terms of an arbitrary unit, which we call a "volt." One volt is about the pressure produced by a single cell of such a chemical battery as is ordinarily used in the operation of telegraph lines, or the transmitters of telephone systems.

We can measure the resistance which the electrical pressure overcomes, and this we do in terms of a second arbitrary unit, as "ohm." One ohm is about the resistance of a wire of pure copper one-tenth of an inch in diameter and one thousand feet long.

The number of volts of pressure or electro-motive force which are expended or which disappear (or are converted into heat or some other form of energy) in overcoming the resistance of each ohm, we call "amperes," and as before noted, we often speak of this expenditure of volts as a "flow" or a "current," though this mode of expression is not accurate, because so far as we know, nothing changes its location when a current of electricity is propagated from end to end of a conducting wire, excepting only the

molecules of which the conductor is composed, which are supposed to be thrown into violent and peculiar vibration, which vibration is communicated from point to point along the circuit with constantly decreasing intensity until the power that causes it is entirely expended, and equilibrium is restored.

The electrical power which is expended in any circuit, that is, the rate of doing work or expending energy, is also measured, and is the product of the total pressure used up in that circuit (volts) multiplied by the rate of expending this pressure in each ohm (amperes) and is designated in units of "volt-amperes" or "watts." An expenditure of seven hundred and forty-six watts during the period of a second of time is equivalent to the expenditure of a mechanical horse-power, or the lifting of five hundred and fifty pounds against the force of gravity to the height of one foot in the same time, one second. We may, therefore, measure the electrical energy utilized or wasted at any point (or between any two points) in a circuit, in units of watts.

The pressure or tension which is thus the useful agent in electrical distribution is felt at all points on a conductor as a strain or effort of the current to pass over or break through the environments which we place around its path in the form of the covering or individual "insulation" of wires, the supports by which the wires are suspended, and the air by which they are surrounded. The cotton or other winding or braid upon conducting wires, the insulating supports, such as wooden cleats, porcelain or glass knobs, rubber tubing and similar material, are useful in confining the electric current upon the copper wire simply because they are poorer conductors than the wire itself; that is, they offer a greater resistance to the expenditure of the electric pressure. None of them entirely prevents the propagation or transfer of this pressure in directions that we do not desire, as, for example, from the outgoing to the incoming wire of a circuit by a shorter path than is offered by the wire and the useful "translating devices" by which the electrical energy is converted into the desired form, as, for example, the lamps by means of which the electric current is translated into light. Delicate measurements show every known substance, even the air with which a suspended conductor is surrounded, to have the power of conducting electrical pressure in some degree, be it great or small, and thus it is impossible to so thoroughly insulate the conducting wires of an electrical circuit but what some fraction of the energy which is developed and transmitted by the generator will escape through the insulation as "leakage," and be practically lost. Iron pipes, and the soil or crust of the earth, when saturated with moisture, offer very little resistance, and it is useful to note that the resistance of any substance depends upon three conditions, first, the material itself—iron offers about six times the resistance of copper; second, the mass or cross-section—a wire one-tenth of a square inch in section offers ten times as much resistance as the larger and easier path formed by a wire one square inch in cross-section; third, the length—a wire ten feet long offers ten times as much resistance as a wire one foot long.

The large cross-section of a system of gas pipes, water pipes or the iron framework of a building, and the enormous mass of the crust of the earth with which such piping or framework is usually electrically connected, renders either one of them or all combined, a very easy path or one of little resistance.

DIAGRAM 1.

Underground Electric Lighting System.

RED LINES, Outgoing Conductor. BLUE LINES, Return Conductor. All parts of the system except Dynamo and Lamps laid on or buried in the Ground. BLACK ENCASEMENT OF CONDUCTORS indicates insulating covering.

FIGURES IN CIRCLES indicate volts at the surface of insulation or contacts with Ground

HEAVY ARROWS show working current. SMALL ARROWS show direction of electrical strain and resulting small leakage.

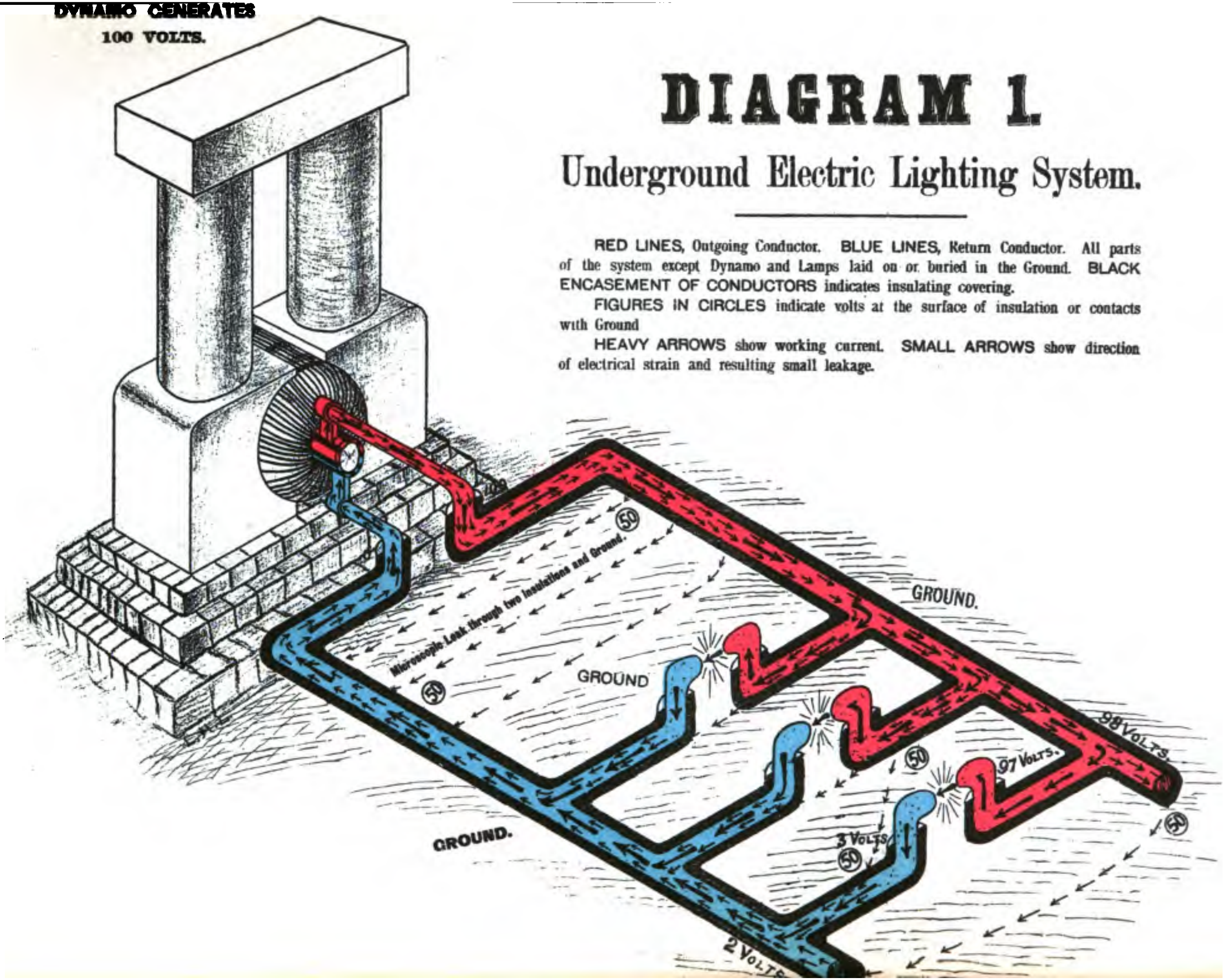


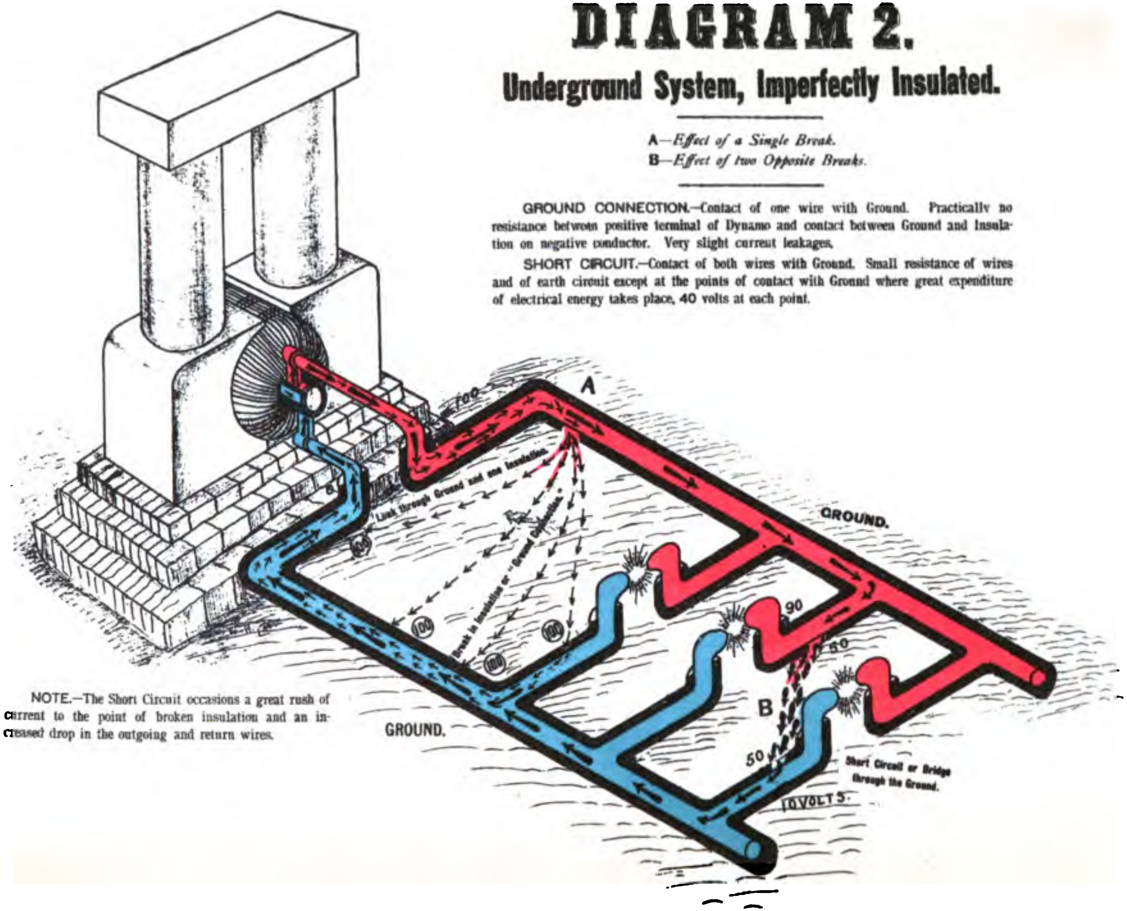
DIAGRAM 2.

Underground System, Imperfectly Insulated.

A—*Effect of a Single Break.*
B—*Effect of two Opposite Breaks.*

GROUND CONNECTION.—Contact of one wire with Ground. Practically no resistance between positive terminal of Dynamo and contact between Ground and Insulation on negative conductor. Very slight current leakages.

SHORT CIRCUIT.—Contact of both wires with Ground. Small resistance of wires and of earth circuit except at the points of contact with Ground where great expenditure of electrical energy takes place, 40 volts at each point.



NOTE.—The Short Circuit occasions a great rush of current to the point of broken insulation and an increased drop in the outgoing and return wires.

If now we assume a generator of electricity insulated from the ground by being placed upon a proper non-conducting or high resistance supports, such as a wooden or brick base, and three electric lamps at a distance from the generator, also placed upon such insulating supports as to prevent any material or serious leakage from their mechanism to the earth, and a covered outgoing conducting wire by which the current is taken from the dynamo and supplied to these three lamps simultaneously, so that a fraction of the entire current passes through each lamp, and if we suppose also that the three fractions of current are, after passing through the lamps reunited and brought back to the generator by a return conductor also insulated, and that both the outgoing and return conductors are buried in the ground, we shall have a system of electric lighting in "parallel" or "multiple arc" which may be graphically represented by "Diagram 1—Underground Electric Lighting System."

In this diagram the dynamo is assumed to deliver to the circuit a pressure of one hundred volts, and a fall or drop in pressure of two volts is supposed to be occasioned by the resistance of the red or outgoing wire, usually called the "positive" conductor. A further drop of one volt takes place in each "branch" on the positive side; each lamp usually absorbs 94 volts, each of the branches on the yellow or "negative" side causes a drop of one volt, and the large return conductor a further drop of two volts, thus expending the entire pressure. The useful currents are indicated by heavy arrows and the lines of lighter arrows indicate the minute currents which, in spite of the resistance of the insulating covering of the wires, shown in blue in the diagram, leak or percolate through the insulation between the positive wire and the ground, through the ground to the surface of the negative covering, and through this covering to the negative wire itself and back to the generator. Assuming that the covering is at all points of practically equal thickness and resistance, one-half of the total difference of pressure between two points on opposite conductors is expended in sending a minute current through the insulation of the positive wire, and the other half in taking the same current through the insulation of the negative wire, the resistance of the ground itself being so small that practically no part of the pressure is expended in passing from the outer surface of one insulation to the outer surface of the other. Thus, the pressure expended in the endeavor to break down the insulation of each wire of the system is about fifty volts, or one-half the pressure developed by the dynamo.

To illustrate some of the electrical effects which may occur in such a system as that of Diagram 1, when this electrical strain upon the insulation of the conductors develops "faults" or "breaks" in the insulating covering, and this increases a minute leakage to one of greater magnitude, we may consider a second sketch, "Diagram 2—Underground System Imperfectly Insulated." This sketch illustrates two sets of conditions. At the left of the diagram the insulating covering of the positive conductor is shown to be so ruptured that the metal of the conductor and the ground are in contact, while no corresponding break appears in the covering of the negative conductor. The small arrows leading through the break and through the ground to four

different points on the negative insulation, through that insulation to the negative conductor, and back to the dynamo, illustrate the strain which is, under these conditions, thrown upon the negative insulation, the surrounding earth being, so to speak, filled with electrical tension seeking at all points to pierce and rupture the one remaining barrier which is interposed between the positive and negative poles of the dynamo by the covering of the negative wire. There being practically no resistance in that portion of the positive wire which is traversed by the leakage currents, and also practically none through the mass of the earth from the point of its contact with the positive wire to the outer surface of the negative insulation, the entire pressure of the dynamo, one hundred volts, is now exerted to break down an insulation resistance one half as great as in Diagram 1. As the volts divided by the ohms gives as a quotient the amperes, it is plain that the expenditure in one thickness of insulation of twice as many volts, will result in a current of twice as many amperes and this means the expenditure in actual energy of four times as many volt-amperes or watts at each point of the negative insulation, and thus the development of four times as much heat and a far greater liability of a rupture of this negative insulation than before the positive break occurred. At the right of the diagram, the effect of two breaks, one on each side of the circuit, is indicated. We may here assume that the insulation is so broken down on the positive and also on the negative wire as to admit a great rush of current, that is to say, many amperes, and a consequent drop in pressure of ten volts on the positive, ten volts on the negative and forty volts at the point of contact between each of these wires and the ground; the resistance of the ground itself being practically of no consequence. Such an expenditure of voltage may practically indicate an instant transformation of many electrical horse-power into heat at each point of leakage, and if the surrounding material be combustible, a fire may thereby be caused on each side of the system. Such a bridge of abnormal character between points where the insulating covering of the wires becomes broken, is usually called a "short-circuit," and the mischief which it may cause is often entirely independent of the amount of electrical energy which may be actually expended, though in cases where the mechanical power which is applied to the dynamo, and the capacity of the dynamo itself to maintain its normal pressure, even when a great amount of current is being generated, are both considerable, the actual heat developed by a short circuit is sufficient to do a great amount of damage.

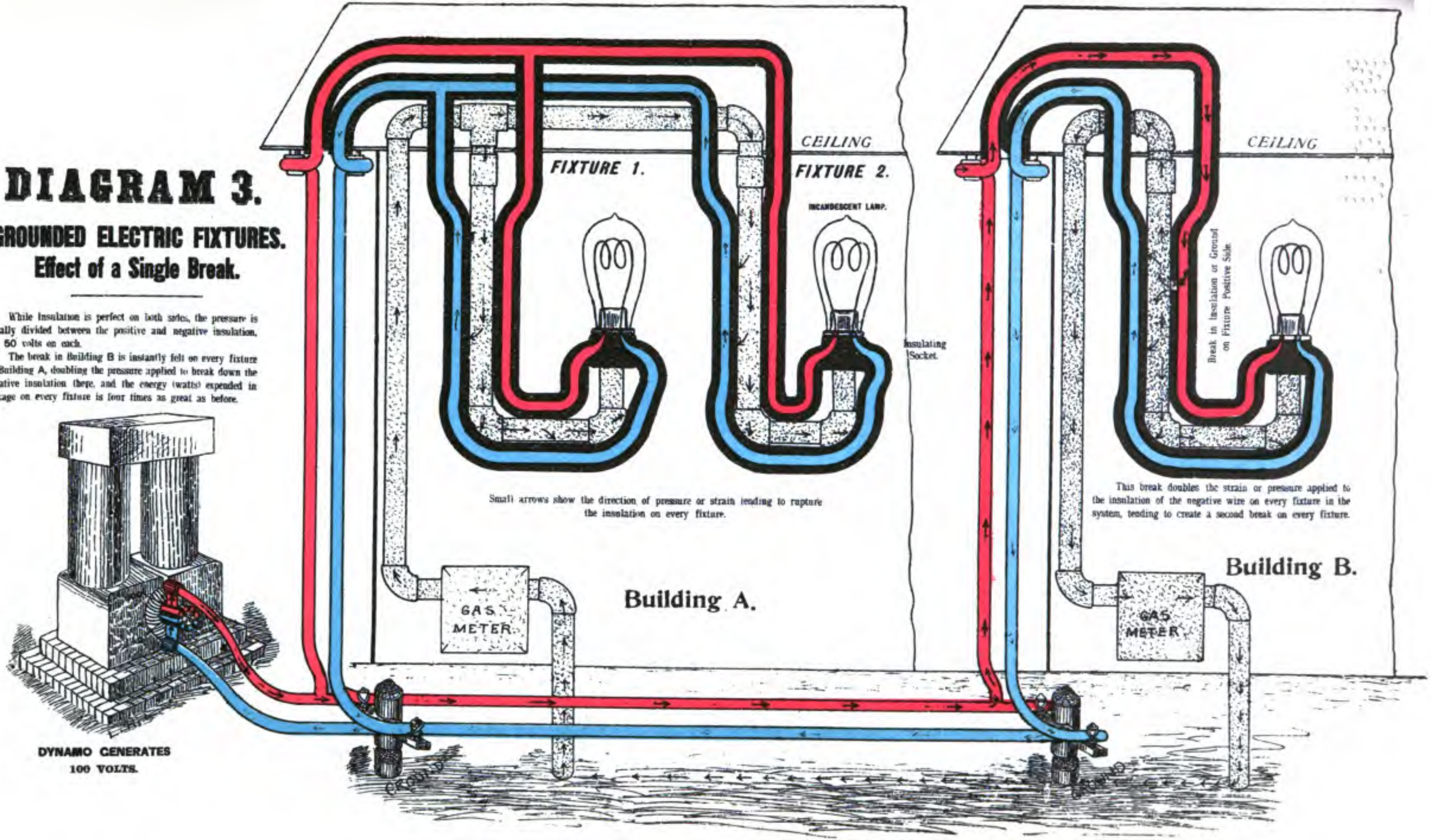
In the practical work of installing such systems of electric lighting as are illustrated by Diagrams 1 and 2, while it is sometimes difficult to insulate the conductors so thoroughly as to avoid annoying leakages on that portion of the system which is outside the walls of buildings, such leakages are in themselves a matter of much less danger than those which take place where conductors of opposite polarity, or having a considerable difference of electrical pressure, are of necessity brought near together in their passage through the walls and floors and along the pipes or fixtures upon which incandescent lamps or similar translating devices are usually supported. This idea will be illustrated by "Diagram 3—Grounded Electric Fixtures; Effect of a Single Break." In this diagram the dynamo which has been

DIAGRAM 3.

GROUNDED ELECTRIC FIXTURES.
Effect of a Single Break.

While insulation is perfect on both sides, the pressure is equally divided between the positive and negative insulation, say 50 volts on each.

The break in Building B is instantly felt on every fixture in Building A, doubling the pressure applied to break down the negative insulation there, and the energy (watts) expended in leakage on every fixture is four times as great as before.



illustrated in Diagrams 1 and 2, is assumed to be connected with an overhead system of conductors suspended from glass insulators on poles in the ordinary manner, a positive and a negative supply-wire being led into each building to be lighted. "Building A" is shown as being piped for gas, with two single-light fixtures suspended from the gas-pipe system, and thus in electrical connection with the ground, each of these fixtures serving as a support for the "insulating socket" in which the electric lamp is placed, and to which the wires which supply the the lamp with current are permanently attached. "Building B" has one such gas fixture, holding a single lamp and socket. The overhead exterior wires of such a system may or may not be covered with one of the ordinary forms of insulating braiding or wrapping. As they are supported only by suitable glass insulators and surrounded by the non-conducting air, it is only necessary that they be kept at such a distance apart as that they shall not be accidentally swung or blown together. From the point where the positive wire enters the building to the lamp socket, and thence returning to the point where the negative wire leaves the building, it is desirable that each of the conductors be well covered with insulating wrapping. They may, however, be kept at such mechanical distance from each other in their passage through walls, floors and ceilings, and they may also be kept at such a distance from any gas, water or other pipes near which they may run, as to incur a less serious risk of grounding or short-circuiting contacts than exists where they emerge from a wall or ceiling and approach each other at a fixture. Diagram 3 illustrates the strain which is brought to bear upon the insulation of both the positive and negative wires when each is brought into close proximity to a metallic pipe or similar conducting body which, though normally carrying no current, and though not of necessity interfering in any manner with the proper operation of the system, so long as the conducting wires are each suitably insulated from it by a proper covering, is a perpetual element of danger, because it is always ready to act as a bridge by which, when any break in the insulation of one wire takes place, the electrical strain may be carried over from the point of that break and applied as an intensified force tending to break down the insulation of the opposite wire, precisely as the earth has been shown in Diagrams 1 and 2 to be a menace to a system of conductors buried beneath its surface. Indeed, in such a system as that of Diagram 3, the gas-piping of buildings and the fixtures attached thereto form simply an extension of the ground itself, the different gas services and the piping of fixtures reaching out from the earth like arms or tentacles, ever striving to attract from its legitimate circuit the current which may be carried by wires which come in contact with them. By means of such gas pipes, together with other systems of piping, carrying water, steam or drainage, the earth becomes, even in the upper stories of the tallest buildings, practically omnipresent, so difficult is it to avoid coming into contact with its numerous branches.

In "Building B" the break which is supposed to have occurred in the positive insulation allows a small flow of current to take place even when all the lamps of the system are extinguished, (and when no current is usefully employed in producing light) along the red wire to the point of the break, where it is communicated to the gas pipe, and follows its metal to the

ground through which it is conveyed to the piping system of "Building A," and the intensified electrical strain is applied to the two fixtures there suspended, tending to rupture the negative insulation.

"Diagram 4—Grounded and Insulated Electric Fixtures," shows what occurs when the negative insulation of "Fixture 2" in "Building A" breaks down under the additional strain caused by the positive ground of the fixture in "Building B." The heavy arrows show how a rush of current is sent along the positive conductor of the pole line, the branch or service conductor supplying "Building B" to the point of rupture, from which it follows the gas-piping and the ground, along the line of the electrical tension or strain indicated in Diagram 3, until on reaching the break in the negative insulation on "Fixture 2," it returns to the dynamo by the negative wire. This rush of current is likely to cause the expenditure of a large amount of electrical energy at the two points of contact between the wires and the pipe, precisely as shown in Diagram 2, with several additional features of disadvantage and danger. If the pipe, which under such circumstances becomes a conductor, is filled with gas, the heat developed at the point of contact may be expected to melt the metal and allow the gas to escape and become ignited by the electric "arc" formed at this point of comparatively poor contact. Such an abnormal current has often resulted in heating the wires concealed within the walls of buildings, or on the fixtures, so as to set fire to the insulating covering, or to the wood or other combustible material upon which the wires may be supported, or by which they may be surrounded. Hence, such a short circuit as Diagram 4 depicts, might be the cause of a serious fire in each of the buildings. The same result in one of the buildings might follow if one of the ground connections were to occur on the line wire outside, as, for example, if this wire were to come in contact with the metal of a gutter-pipe connected with the earth; or it might occur in consequence of a faulty insulation of the dynamo itself, by which the conducting portions became connected with the ground. From this it will be plain that the idea of bringing the conducting wires of an incandescent electric lighting system into intimate contact (but for the protection afforded by their insulating covering) with gas pipes or other grounded supports within the walls of the buildings, was after some unpleasant experiences justly regarded by the managers of the first central lighting stations, the owners of isolated plants, the customers to whom electric light was supplied, and the fire insurance underwriters who assumed the risks of buildings and other property, as a serious hazard.

There have been found to be three ways of avoiding difficulty by leakage under such circumstances.

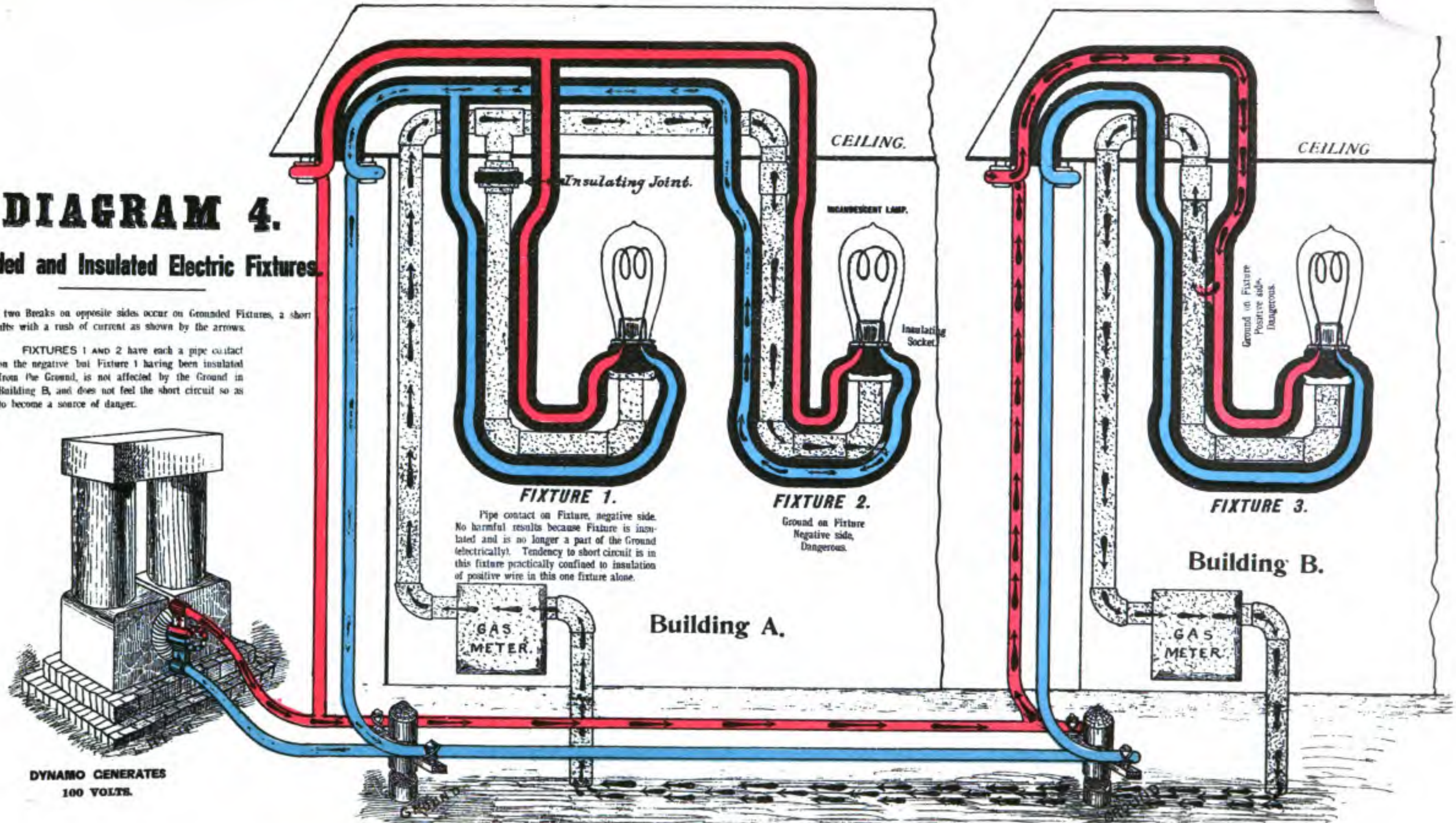
(1) By improving the quality or thickness, or both, of the initial primary insulation, that is, the wrapping of flexible non-conducting material which forms a part of the conductor itself as sold to the constructor. The "Primary" insulation may be said to include whatever non-conducting substances stand between the current-carrying wire and supporting conducting material to which we are afraid the current will escape. The "initial primary" insulation, means, as the phrase is here used, the rubber sheath or cotton braid or winding or other flexible wrapping which is originally applied.

DIAGRAM 4.

Grounded and Insulated Electric Fixtures.

When two Breaks on opposite sides occur on Grounded Fixtures, a short circuit results with a rush of current as shown by the arrows.

FIXTURES 1 AND 2 have each a pipe contact on the negative but Fixture 1 having been insulated from the Ground, is not affected by the Ground in Building B, and does not feel the short circuit so as to become a source of danger.



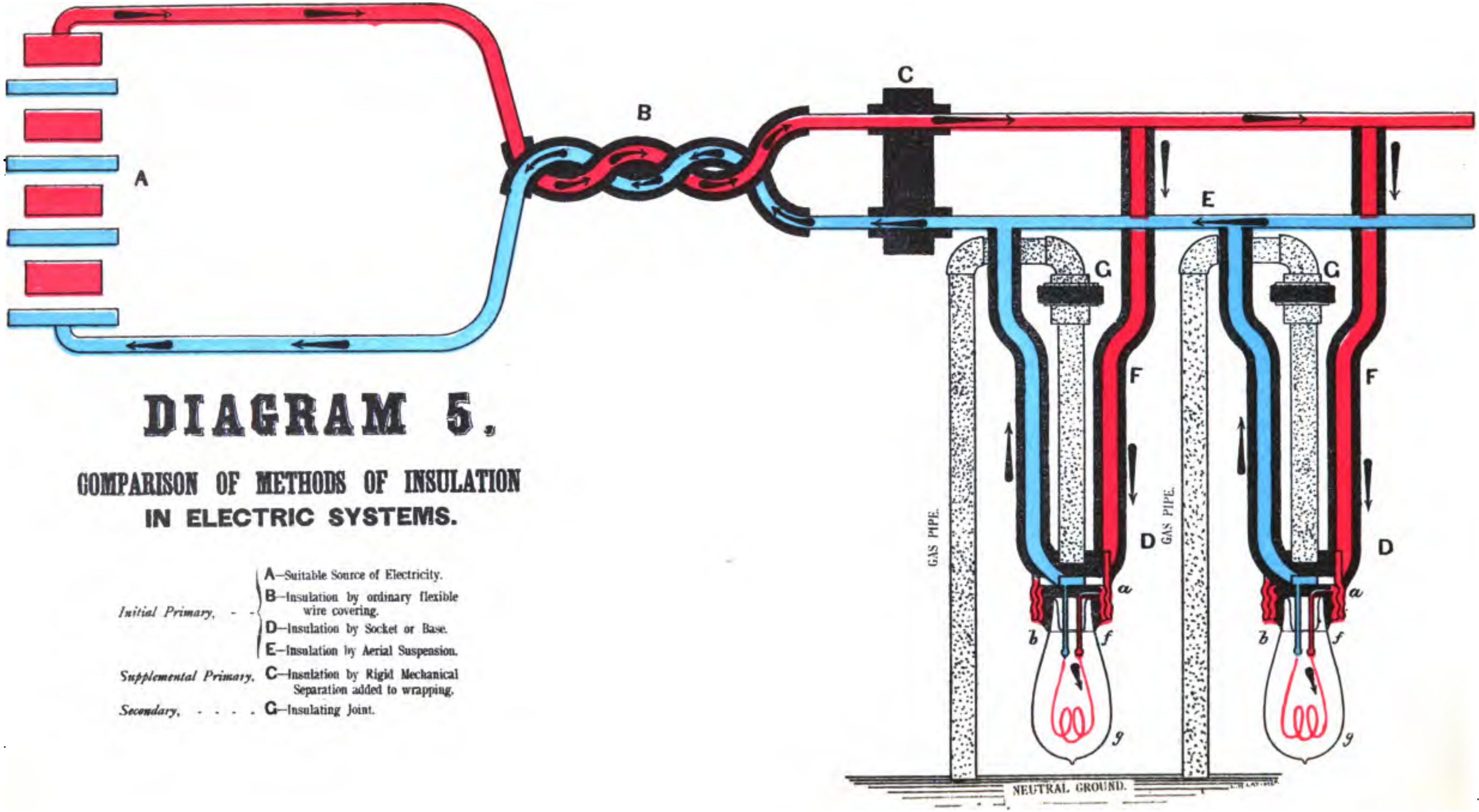


DIAGRAM 5.

COMPARISON OF METHODS OF INSULATION IN ELECTRIC SYSTEMS.

Initial Primary, - -
- A—Suitable Source of Electricity.
- B—Insulation by ordinary flexible wire covering.
- D—Insulation by Socket or Base.
- E—Insulation by Aerial Suspension.

Supplemental Primary, C—Insulation by Rigid Mechanical Separation added to wrapping.

Secondary, ... G—Insulating Joint.

(2) By adding to the "initial primary" insulation a reinforcement of outside and usually rigid material, such as as ordinary glass telegraph insulator, a porcelain or wooden cleat, a hard rubber tube, an insulating conduit, or a flexible material, such as a winding of rubber tape, forming a "supplemental primary" insulation so that the amount of resistance which the electrical pressure will have to overcome before it can leak to any fairly good conductor, will be greatly increased. The combination of the "initial" and "supplemental" primary insulations is shown in Diagrams 3 and 4, and more clearly illustrated in "Diagram 5—Comparison of Methods of Insulation in Electric System." It is exemplified wherever a covered wire is attached to a glass or porcelain insulator, or supported by a wooden or porcelain cleat.

(3) By the combination of one or both the foregoing methods with a "secondary" insulation which separates two sections of conducting material, neither of which is connected with the circuit, so that if a leakage is accidentally developed in one section it cannot pass to the other. A "secondary" insulation within the meaning of this definition is an emergency device, and is well exemplified in the common "insulating joint" by which the present rules of the Underwriters of this country require that all fixtures carrying electric lamps, or such lamps in combination with gas jets, shall be electrically separated from the gas piping of the building by which they are mechanically supported.

In Diagram 5 are shown these methods of applying insulating material. A represents (by the symbol usually employed to indicate a battery of chemical cells) any source of electrical energy which may be used to supply such a system. B illustrates the insulation of the positive and negative conductors from each other by ordinary forms of "initial primary" winding, braiding or wrapping. C indicates a rigid form of insulating material—such as, for example, a wooden cleat—which separates the conductors electrically, and also mechanically, at a given distance, and is usually employed in connection with the wrapping or other insulating covering shown at B, to give additition security against leakage, thus combining the "initial" and "supplemental primary" ideas. D shows a block of insulating material, such as is ordinarily used as a base, socket or holder for a translating device. This base or socket application may combine the useful features of both forms of insulation shown at B and C, if the initial wrapping is carried through the non-conducting base, because it electrically separates the two conductors from each other by two co-operating thicknesses of insulation and also holds them rigidly at a definite mechanical distance apart. In addition, it has a third utility in that it also insulates both conductors from any metallic conducting support upon which it may be placed, such as a gas pipe; and finally, it serves the purpose of sustaining the translating device in any desired position. The diagram shows two such insulating bases or sockets with a translating device attached to each, to illustrate the usual method of connecting incandescent lamps in "multiple arc," although the general form, and, speaking generally, the usefullness of this application of insulation is the same when such translating devices are connected in "series," or in such a manner that the current is sent through them successively, that is, one after another. E illustrates primary insulation by aerial

suspension, which is, under ordinary circumstances, the best as well as the cheapest means of providing against leakage from circuits of high potential or pressure. F indicates the specially taxing position of insulation where conductors are maintained at a certain mechanical distance apart by an intervening body of conducting material, or, what is electrically equivalent to this, are surrounded by a conducting pipe, and depend entirely upon the perfection of the insulation covering surrounding each of them, for the reliability and safety of their operation. G represents the "secondary" application of insulating material in the form of the insulating joint by which two conducting bodies, neither of which normally carries current, are electrically separated and at the same time mechanically united.

In "Fixture 1" of Diagram 4, appears the efficacy of the insulating joint in preventing a short circuit, even when the negative insulation becomes impaired, as was supposed in the case of "Fixture 2." The electrical separation or insulation of that portion of the gas pipe with which the system of wiring comes into close contact in this "Fixture 1," prevents the rush of current which traverses the pipe system of the building from entering the pipe of "Fixture 1" at all, and hence the break in the negative insulation upon it has no effect upon the electrical condition of this insulated section of gas pipe, at least no effect capable of producing dangerous results in connection with a break on the opposite side of the circuit in another fixture.

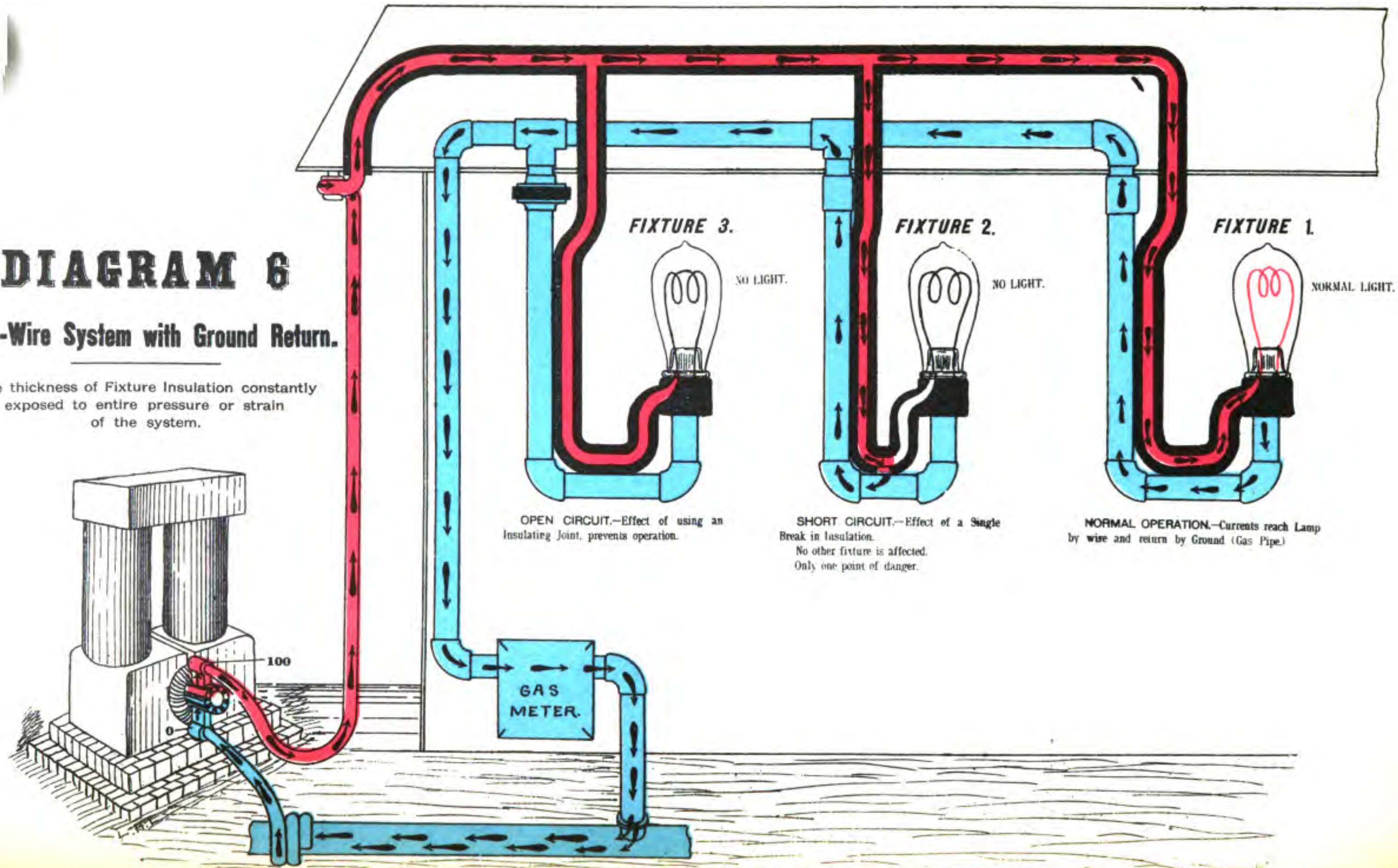
Hence, if we suppose a system supplying current to lamps on 1000 separate fixtures, all of these fixtures being in electrical contact with the general gas-pipe system and the earth, a single ground connection on any one of these 1000 fixtures will result in practically doubling the electrical strain on each of the 999 remaining fixtures, and will finally result in the breaking down of the weakest spot which exists in the insulation of the wires on any one of them. Thus the chances of short circuits become very great. If, now, we suppose all of these fixtures to be supplied with insulating joints, the chances of a short circuit through the metal of the fixtures are reduced at least from 1,000 to 1, because the only means by which a short circuit can be developed after the application of the insulating joints is by the breaking down of both the positive and negative insulation on the same fixture or the failure of the insulating joints themselves, either of which, with reasonably good construction, is very unlikely. By means of the insulating joints that portion of the branch or arm, or tentacle of the ground, which is, by reason of its serving the purpose of a mechanical support for lamps, sockets and wires, most likely to connect these electrical devices with the ground, and through it with other parts of the same electrical system, is electrically detached and thus robbed of its ability to do mischief. It still maintains within itself its ability to act as a conducting bridge or short-circuiting medium, but its dimensions have been, by the insulating joint so curtailed that it becomes a useful and reliable device instead of a perpetual menace. Upon it is placed the insulating socket which electrically separates the lamp terminals of the two supply wires from each other, and also from the supporting pipe.

In such a system each of the conductors of the metallic circuit is to be carefully insulated from a conductor of opposite polarity and also from the

DIAGRAM 6

One-Wire System with Ground Return.

One thickness of Fixture Insulation constantly exposed to entire pressure or strain of the system.



metal of the fixture, and this double insulation is to be secured, not only by the separate covering of each wire, but by a connection with permanent terminals in an insulating socket, so arranged that the metal of the wires, which is necessarily here exposed by removing the insulating braid or wrapping, shall be rigidly kept apart from each other and also from the metal support upon which the socket may be mounted, usually one of the arms of the fixture. The metal portions of the fixture, though made of conducting material, are thus treated as normally "neutral" in an electrical sense, that is, having no electrical connection with either the positive or the negative wire, and presumably intermediate as regards these conducting wires, in the sense that the ground is, in Diagram 1, intermediate in its potential between the positive wire, representing a high degree of pressure, and the negative wire, representing a low degree. Diagram 4 graphically depicts the disastrous effects which may follow an accidental connection of either of the connecting wires with the metal of the fixture pipes when these fixture pipes are all inter-connected by a general system and by the ground, because in such a case these pipes become a sort of ever-present bridge or channel of leakage by which current which escapes from the positive wire to the pipe of a fixture in one house may traverse this pipe and the earth and make its way to the negative wire in a fixture in another house, perhaps a long distance away. The insulating joint diminishes the danger of such accidents by cutting this inter-connecting network or leakage channel into as many short sections as there are fixtures to be wired, or, by electrically cutting away from the trunk of the tree each branch at the point where its dangerous work begins. The same advantage would be secured in a system of electric light fixtures suspended from the iron framework of a building, because the frame would act precisely like a gas-pipe system in carrying current from one fixture to another.

"A one-wire system," is exemplified by an incandescent electric lighting multiple arc circuit in which one terminal of the generating dynamo—for example, the positive—is connected with the insulating sockets of the lamps by a wire suitably insulated, and the return circuit from these sockets to the dynamo consists in whole or in part of the gas-piping system of the building or the earth. Such a system is shown in "Diagram 6, One-Wire System with Ground Return." It is usual in discussing the electrical peculiarities of a system of this kind, particularly where the larger portion of the return circuit is made up of underground pipes or by the large mass of the earth itself, to consider such return circuit as offering no practical resistance to the passage of such currents as it may be called upon to carry. As a matter of fact, it has been found that while a ground return is available for such small currents as are ordinarily employed in telegraph, telephone, fire-alarm, district-messenger, and similar systems, the resistance of the contacts between the metallic conductors and the mass of the earth, where both are employed, and the uncertainty of the condition of the soil itself as to the amount of moisture, and the percentage of particles of conducting material which it may contain, combine to make the conductivity of a grounded system variable, and the contacts between sections of the conductor, upon which this general conductivity depends in a large measure, so uncertain that no definite calculation can be made in advance as to the amount of

drop in pressure which will be experienced in the return portion of the circuit. In general, however, it may be said that, if it were commercially feasible to use one-wire circuits with ground return for electric lighting and other similar purposes, it would require only one-quarter of the weight of copper wire (to transmit a given current to a given distance and return with a given percentage of drop in pressure) that is ordinarily required for a system using a complete circuit of wire without the aid of the ground or of its connecting pipes. For instance, if we suppose the drop in pressure which occurs in the positive conductor of Diagram 6 between the dynamo and the lamps to be two volts, and the drop in the return circuit of iron pipes and ground to be practically nothing, we lose two per cent. of the 100 volts generated by the dynamo. If, instead of the grounded return, we were to run back a copper wire of the same size, we should in that return wire lose another two volts, or four per cent. in all. In order, therefore, to bring down this loss of pressure to the two volts (or two per cent.) to which it was formerly limited, we must double the size of both the old positive and the new negative wires so that only one volt loss will occur in each. This results in two wires each twice as large as the former single wire, or four times the mass of copper, as already stated.

In the early history of electric lighting numerous attempts were made to make the earth thus save three-quarters of the copper or other conducting wires, as it had done in prior telegraph, telephone and other systems. A "parallel" or "multiple arc" electric light plant constructed on this principle was for some time operated by the United States Electric Lighting Company from a station in the Equitable Building in New York City, and a second "one-wire circuit" was also operated from a station at the corner of Sixth avenue and Twenty-sixth street, by the same company. The apparent economic advantage and the simplicity of construction of a system which required only one conductor, and lamp sockets which separated one terminal from the other, but separated only one terminal from the gas pipe, was broadly advertised and thoroughly discussed at that time, as well as in other instances where similar attempts were made. It was soon found, however, that the advantages were only apparent and not real, or rather that they were overbalanced by disadvantages of unreliability of the earth circuit, and also by the consideration that the entire working pressure of the system was under all circumstances applied to the single insulation between the positive wire and the gas-piping of a building or other earth connections upon which lamps might be supported, and that thus the condition of a double strain and a quadruple expenditure of electric energy tending to short-circuit the system, which has been discussed in connection with Diagram 1, was constantly present in a system like that of Diagram 6; also, that only one grounds connection was necessary to produce a short-circuit, instead of two ground as in the two-wire system shown in Diagram 4. The three electric lamps of Diagram 6 illustrate three conditions possible in such a system. Fixture 1 illustrates a practically perfect insulation of the positive conductor from the negative gas pipe, and consequently a normal flow of current through the lamps so long as the pressure is kept constant at its terminals. Fixture 2 shows the effect of a single break in the insulation, namely a short circuit with a rush of current through the reduced resistance thus

occasioned, with a liability of fire, the same as in the case of the short circuit of Diagram 4. In this Fixture 2 the occurrence of a short circuit is usually accompanied by such a fall in the pressure applied to the lamp as to greatly diminish or practically extinguish its light. Figure 3 shows what happens when an insulating joint is introduced, (as in the case of Fixture 1 of Diagram 4) to electrically separate the metallic portions of the fixture from the gas-pipe support above. This entirely stops the operation of the lamp on the fixture so treated, and hence an insulating joint is out of place and has no legitimate use in connection with the one-wire system using the gas pipe of the fixture as part of the circuit.

The principal importance of the illustrations presented by these diagrams lies in the fact that the iron pipes which they show exemplify also the paths for leakage of electrical energy, "short-cuts" to earth or from one pole to the other, which are often afforded by damp beams, plaster and other building material. Such paths usually conduct the current with more difficulty or less facility than the pipes, and are often even more dangerous because the greater resistance develops proportionally greater heat, and because by reason of its combustibility the wood itself may be carbonized by the current it carries, as a green tree will sometimes be set on fire in a wet night by an escaping current of high pressure.

ORIGIN OF ELECTRICAL INSURANCE RULES.

It is interesting and instructive, now that the possible sources of danger to property from the presence of electric light and power circuits are well understood and rules have been formulated and can be enforced which practically counteract these dangers, to glance at the indefinite and somewhat contradictory views held by those most intelligent in applied electricity less than twelve years ago, by quoting from publications of that time some extracts showing the fears entertained by the electric lighting companies themselves and also by the fire insurance fraternity, of accidents and damage by the escape from proper control of currents representing mechanical forces, either for usefulness or for mischief, vastly in excess of any which had been employed in the prior applications of electricity.

The underlying principles of the distribution of electrical energy to electric lamps, whether arc or incandescent, were the same that had for many years been utilized in its distribution for the purposes of telegraphy, gas-lighting devices and the like, because these prior forms of translators had been operated both in series and in multiple arc; but, as I have before indicated, the very small expenditure of electrical potential in each unit of the resistance of a gas-lighting circuit made the energy which could possibly be concentrated at any one point so insignificant in its capability of doing mischief that when the electric lighting systems proposed to expend many volts in each ohm of the resistance of the circuit—or, in other words, to employ many amperes—the mechanical horse-power represented by such lighting currents demanded the most extraordinary care in the matter of keeping the electrical energy on the wires—or, in other words, in the matter of keeping the circuit effectually insulated from everything which would tend to divert forces of dangerous magnitude from their proper paths. It is not surprising that the first electric light constructors and insurance experts should have

failed to appreciate the dangers to life and property which were afterward found to result from an ignorant or careless method of insulating circuits proceeding from dynamos operated by powerful steam engines and similar sources of energy.

The following letter from a representative of the insurance interests who has always stood in the front rank of progress in all that pertains to practical security from fire, illustrates the state of knowledge prior to 1880:

BOSTON MFRS. MUTUAL FIRE INS. CO.,
BOSTON, MASS., Nov. 21, 1879.

G. W. STOCKLY, ESQ., V. P., Telegraph Supply Co.

Dear Sir: You are at liberty to say that this company prefers the electric light (so guarded that points of incandescent carbon cannot fall from it) to any other known mode of lighting, having as yet been unable to find any cause of danger in its use, except as above stated. Yours very truly,

EDWARD ATKINSON, President.

At the time the above was written the arc lamp was the only practical device for electric lighting.

There were, even as late as 1881, very few men engaged in electrical work who had any well defined idea of the distinctions which should be drawn as between the insulation of multiple arc circuits, and of series circuits employing very much higher pressure. In the multiple arc circuit, while the total pressure of the system was, and is, usually restricted to a comparatively low standard, the amperes of current are limited only by the number of lights connected with a given system; and, as the heating effects produced in a given circuit increase directly as the square of the amperes, any material rise of current strength was found to cause a very dangerous condition of things. It was to obviate this danger that the attention of the insurance people was at first directed to the regulation of the covering or insulation by which electric light wires were to be protected, so that an abnormal heating of the wire might not result in setting on fire the insulating covering, and thus the combustible material by which this insulation might be surrounded or supported. It was also discovered that leakages to earth, which had always occurred to a greater or less extent in the history of all prior systems of electrical distribution, resulted in something very much more serious than a mere temporary interference with the working of the system and the convenience of the user, because such leakage might, when backed by the powerful dynamo and steam engine, develop such great heat energy as to frequently set fires.

These new conditions in the operation of electrical apparatus and the apprehension which they excited in the minds of the fire insurance fraternity, are clearly set forth in a paper read at the first annual meeting of the United Fire Underwriters in America, by William A. Anderson, of New York, Nov. 16, 1881, entitled "The Dangers of Electric Lighting." In presenting this paper, Mr. Anderson represented the New York Board of Fire Underwriters, and also (as its chairman) a committee of that board called the "Committee on Police and Origin of Fires." The following are brief extracts from this paper, which was printed in pamphlet form at that time, and of which copies are still preserved in the office of the New York Board:

"Electric lights are now so rapidly being introduced into our larger stores, hotels, mills and manufacturing establishments, that it becomes the duty of underwriters to carefully examine into the question, and if danger exists, to take prompt and decided measures to guard against the same at every point.

"The New York Board of Fire Underwriters, some months ago, delegated to their committee on Police and Origin of Fires, this duty, and in their investigations (which have occupied considerable time and attention, and which are now only partly performed) they discovered the evidence of existing and threatened danger of a serious character.

"To guard against the same, the said board, upon the recommendation of this committee adopted a preliminary standard of requirement for 'electric lights, wires, lamps, etc.,' which will be amended and added to from time to time, as they learn more of the subject, and as necessity may demand.

"First. 'Wires to have fifty per cent. excess of conductivity above the amount calculated as necessary for the number of lights to be supplied by the wire.'

"It is currently reported that the several fires that occurred at the Paris Exhibition were mainly caused by thin wires and contact of wires.

"If a wire has not conductivity sufficient to carry the current of electricity the wire will become heated, and, if insulated, will burn the insulation, and, if not insulated, will burn whatever combustible substance it comes in contact with, and also consume the wire.

"Second. 'Wires to be thoroughly insulated and doubly coated with some approved material.'

"The New York committee were strongly in favor of recommending that non-inflammable covering only should be used; but it was represented to them, and it has since been proved by test, that some of the insulating compounds, in themselves inflammable, are better insulators for electrical purposes, and until this particular point is better understood they recommend the use of such doubly covered insulators as shall be approved; and it is the intention of the committee to test, as far as possible, a sample of each wire submitted, by applying to it a current of electricity greater than the amount calculated to be used, and also to ascertain by test whether it will stand contact with conducting substance without burning.

"The New York committee, through their inspector, found many of the wires—and, in fact, it may be said most of the wires—that were placed in buildings previous to the Underwriters' action in the matter, were without proper insulation and some without any covering whatever; and if any underwriter has the least doubt as to the danger of such equipment, we would ask him to cross-circuit such wires with one of a smaller size and watch the results.

* * * * * *

"Some covered wires are now in use that appear to be safe; but we firmly believe that if electric lights are to be permanent with us, that the wire of the future must be different from any now in use for, in our opinion, full protection to life and property require that the conductors of so strong

an agent should not only be covered with a substantial insulator, but in addition to be firmly encased in a leaden pipe, or in some such manner protected from wear and friction.

"'Third. All wires to be securely fastened by some approved non-conducting fastening and to be placed at least two and one-half inches for incandescent lights, and eight inches for arc lights, from each other, and eight inches from all other wires and from all metal or other conducting substance, and to be placed in a manner to be thoroughly and easily inspected by surveyors.'

* * * * * *

"'The conducting framework of the chandeliers and lamps must be insulated and covered the same as wires.'

"One illuminating company is now engaged in laying their street system, which consists of two copper wires or rods insulated from each other and from the heavy iron pipe in which they are enclosed—the whole buried about two feet in the ground.

"Insulated wires will connect with the house main at each floor; and at each junction from the street main, service main, house main, and, in fact, at each connection up to the lamp socket, at the base of the chandelier, the company propose to have an automatic fusible 'cut-off,' called a safety catch, which they claim to be a complete cut-off in case of crossing of wires, accident to lamps, or any contact with conducting substance that may cause any increase of resistance or unduly heat the wires. (!)

"In some few cases, circuits have been found grounded by the conducting wire being fastened to a gas or water pipe.

"This should never be allowed, for it largely increases the chances of the electric current being carried to the telephone wires, and by the latter to telephone instruments causing fire in them. And another danger to be apprehended in grounding of wires is the fact that a bad joint in a gas pipe may be of such poor conductivity that the passage of a current of electricity in large volume would be likely to heat the pipe red hot, and ignite escaping gas."

The general feeling of apprehension which was excited by a better knowledge of the subject on the part of the fire insurance company is further illustrated by a series of reports made early in 1882 by Mr. Edward Atkinson, as President of the Boston Manufacturers' Mutual Fire Insurance Company. The first of these was entitled "Electric Lighting No. 1," and was dated "Boston, January 16, 1882." Two or three paragraphs will indicate its tone.

"We are engaged in making all thorough investigation as to the alleged dangers which may occur from the electric light and other matters connected therewith.

* * * * * *

"The greatest care should, therefore, be taken in choosing the position of the wires; and they should never be carried along the under side of the beams and transverse thereto, or in any proximity to belts, shafting or pipes.

"The danger of suspended wires exposed to the action of machinerv will be apparent. We are not yet fully prepared to suggest the true method

of placing wires and protecting them; but, having indicated the danger, we ask suggestions from those who have used the electric light, in order to enable us to work out the proper instructions.

* * * * * *

"It may be added that we have not yet found any cause or danger of fire from the use of the electric method of lighting which may not be avoided if the right method and proper care be used in putting up and operating the apparatus; but electricity is a force which cannot be too carefully controlled, directed and watched, if generated in currents of considerable intensity."

The third of these reports of Mr. Atkinson was entitled "Electric Lighting No. 3," and was dated "Boston, March 6, 1882." Among other significant utterances were the following:

"In view of the apparent novelty in the application of electricity now made or contemplated and the indefinite sense of danger which pervades the community regarding its use, it may be as well for us to assume that most of our members are now, or were lately, in the same condition of mind as ourselves; to wit, suddenly called upon to investigate a subject of which they knew little, described in a technical language of which they knew nothing.

"We use the expression 'apparent novelty' for this reason—the application of this source of energy, named electricity, to the production of light or to the transmission of power, is in fact no novelty whatever; all that has happened in these later days has been what many persons, who have not examined the subject, are still supposing to be in the somewhat distant future, to wit, bringing this force into the domain of applied science so economically as to be commercially useful.

* * * * * *

"Each machine should be used with complete wire circuits, and connection of wires with pipes, or the use of ground circuits in any other method is absolutely prohibited."

ORIGIN OF ELECTRICAL INSURANCE RULES.

In connection with the third of the series of reports, Mr. Atkinson printed a code of "Directions for Running Wires for the Edison Incandescent Electric Light," issued by the Edison Electric Light Company, of New York City, over the signature of C. L. Clarke, of its engineering department, and dated "February, 1882." Among these directions occur the following:

"Whenever a connection is made between a larger and smaller conductor at the entrance to or within the building, our automatic device (the 'safety catch') must be introduced in the circuit of the smallest conductor so as to cut off the current when in excess of the safe carrying capacity of the conductor. The safe carrying capacity of a wire is that current which it will convey without increasing its temperature more than a few degrees above the temperature of the room through which it passes.

"All wires, machines and lamps to be so mounted and secured as to insure complete and continuous insulation, with the exception of those parts

(such as portions of the lamp or machine, for example) where insulation is impossible, and, in this case, accidental contact with exterior objects must be prevented by appropriate screens or the like.

"In no case must 'ground circuits' be employed or any portion of the system allowed to come into conducting connection with the earth through water or gas pipes or otherwise. * * * *

"All wires should be placed at a distance of two and one-half inches from each other, and, wherever they approach any other wire or conducting body capable of furnishing another circuit or ground connection, they must be rigidly secured and separated from the same by some continuous solid non-conductor, such as dry wood, of at least one-half inch in thickness.

"Wherever wires are carried through walls and floors in buildings, they must be surrounded by a special tube of substantial material, and insulated therefrom.

"All joints in wires must be made in such a manner as to secure a perfect and durable contact, and means provided to prevent their contact with any other conducting body."

The "indefinite sense of danger," as Mr. Atkinson expressed it, which at that time pervaded the community, was indicated a few days prior to the reading of the paper by Mr. Anderson from which I have quoted, in an editorial in the "New York Times," of October 28th, 1881. Referring to reported narrow escapes from fires due to the imperfect insulation of electrical conductors, the writer said:

"These are but typical examples of what may be expected when the electric lamp comes into more general use, unless a more perfect and more durable mode of insulation is adopted than that of merely winding the wire with thread or cord, or sheathing it in vestments woven of the same perishable material, liable to become rotten in a short time through the action of the elements, or to be worn away by the sharp friction in a few hours.

* * * * * * *

"If employed in house lighting, they should be carefully boxed—not exposed to abrasion from any accidental cause.

* * * * * * *

"Perfect insulation cannot obviate the danger from fusion by overheating; indeed, the more perfect the insulation, the greater the peril."

Referring to the Times article and in startling contrast with its conservative views, was an emphatic utterance by one of the learned authorities of that period in a reply written a few days later:

"In the first place, let me remark that I fully realize that fires may be caused by the wires carrying the currents used for electric lighting of all sorts, but the conditions of danger are not correctly set forth by the writer of the article in question. In the first place 'the conductor coming in contact with wood-work' will not, as this writer says, 'almost instantaneously ignite it.' On the contrary, it is perfectly safe to have such wires secured with metal staples directly to the wood-work of a building for any distance. The electric current used with these wires is so immensely within the limits of their conductivity or carrying power that it has not the slightest practical tendency to escape, or to heat the wires through which it passes.

"If the wire should be nearly severed or imperfectly connected at any point, then heating and danger may occur at such point as suggested, but the intact wire is as little liable to ignite wood-work along which it runs, as a gas pipe would be, and the latter equally might occasion fire when it is defective and leaking, though the bad smell of the gas decreases its dangerousness in this respect."

There are several propositions here laid down to which the intelligent insurance inspector of today would hardly assent.

From some of the above quotations it is plain that the low pressure systems had, in the opinion of the fire insurance people, provided to a certain extent against the over-heating of conductors and the consequent ignition of their insulating covering, by interposing a safety fuse in the circuit of each branch which diverged from a conductor of larger size, and that they relied upon this fusible section, or weak link in the chain, to protect the circuits and apparatus from the difficulties of leakage and from the fires which might result.

It must be understood, however, that this feeling of confidence was based upon the idea that, in following the rules from which I have also quoted as being issued at the same time, the conductors would be separated from any foreign conducting material, such as a gas pipe, by at least one-half an inch in thickness of a good insulating material of rigid character, such as dry wood. It is also worthy of note that in the code of "directions" just quoted, there is not a word said about the fixtures to which incandescent lamps were to be attached, leaving the presumption that when such fixtures formed part of a conducting system, the wires of the circuit were to be insulated from them with as much care as if they incidentally crossed a gas pipe or a water pipe in their course through a building.

Acting upon their earliest impressions that an insulating covering which would not burn if the wire became red hot (or at all events would not carry fire or support combustion) would answer the purposes of electric lighting, the fire insurance authorities approved a form of insulation consisting of one or two thicknesses of cotton braid saturated with white paint or a similar compound. Conductors thus insulated soon became known to electrical men as "underwriter's wire." They undoubtedly did possess the advantage of being non-inflammable, but it soon became equally notorious that when placed in many positions they would not in any appreciable degree prevent electrical leakage, because they would absorb moisture almost as readily as a sponge. The difficulties which the absorption of moisture might occasion, were understood by comparatively few people who were really engaged in the business of construction, but they soon became evident when small leakages through the insulating covering and across a bridge of moisture-covered or moisture-soaked intervening material to a ground connection or a wire of opposite polarity, developed first a charring of any combustible substance along which the leakage might be conducted, and afterward a blaze. There was, however, in these early years, very little choice offered to the constructor in the matter of conductor insulation. The ordinary paraffine wire used exclusively for interior work in the earlier days of the telephone industry speedily revealed the volatile character of the insulating filling of its cover by drying out and leaving a

simple braid or winding, no protection against moisture. A similar woven cotton cover filled with beeswax was but little better and also very inflammable. A variety of rubber-covered wire, known to the trade as "Kerite," had been used in prior low-pressure work where the small currents of the telegraph and its kindred systems had been employed, but when exposed to the action of the elements, or to the heat of the upper portions of rooms, it speedily became brittle and was often found cracked to the metal beneath.

Such were the insulating flexible coverings with which the early electric light constructor attacked the problem of wiring fixtures for incandescent electric lamps alone, or fixtures providing for both gas and electricity and also the general work of wiring buildings. Their use tended from the first to convince the experimenter of the early months and years of the electric lighting art that the safest method, even in the handling of low-pressure currents, such as those required by the incandescent lamp, consisted in dependence upon the precautions set forth by the directions of the Edison Company which I have quoted, namely, the separation of all such insulated conductors from any foreign conducting body, such as a gas pipe, by at least half an inch in thickness of a rigid insulating material like dry wood, and reliance upon supports of this kind and the aerial suspension from one support to another of which this method allowed, in the running of wires along the main stem or the arms of a gas fixture.

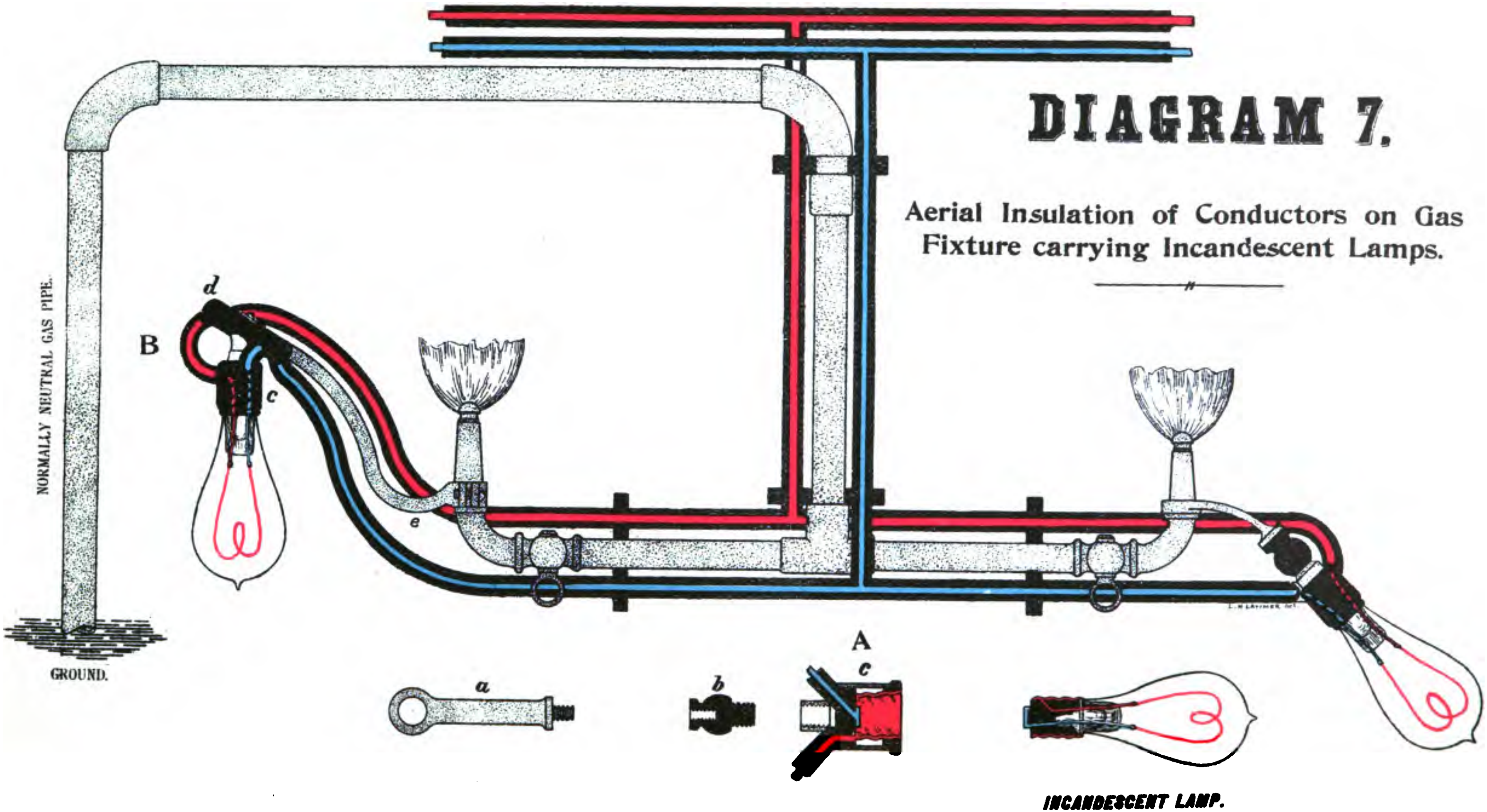
The dangers attending the intimate contact with conducting material of both wires of even a low-pressure system, such as is usually employed to directly supply incandescent lamps, were intensified when both gas and electricity were used in the same fixture, or so arranged that gas under pressure was always present in the main pipe or stem, and electrical tension was always on the wires. While each worked perfectly and independently while under control, there was always great danger that either would, if it escaped from that control, immediately proceed to liberate the other. The gas would at once begin to disintergrate the insulating covering of the wire; the electricity would heat and melt the pipe and set free the gas; with both at liberty there was almost a certainty of fire.

All sorts of clumsy attempts were made to hold the wires at a safe distance from the gas fixture, and one or two of these are illustrated by "Diagram 7—Aerial Insulation of Conductors on Gas Fixture carrying Incandescent Lamps." One plan is shown at A, and involved the use of the metallic spur attachment *a*, the insulating thimble or bushing *b* and the lamp socket *c*, such socket having holes bored through its outer shell for the introduction of the wires. The other device shown at B of the same diagram consisted of a metallic arm *e*, adapted to be fastened to the gas burner by a set screw, and carrying at its lower end a wooden insulating piece *d*, through the opposite ends of which the two wires passed and entered the socket *c* as in the other case.

These unsightly arrangements were rendered unnecessary by the adaptation of the insulating joint to the admission of gas to the main stem and gas arms of the fixtures, and the concealment of the electric wires between the pipes and ornamental shell and within special lamp arms corresponding in general design with the outlines of such fixtures as were acceptable to the public.

DIAGRAM 7.

Aerial Insulation of Conductors on Gas Fixture carrying Incandescent Lamps.



By such means, in connection with the improvement of the insulating wrapping of wires, electroliers, and also combination gas and electric fixtures have been produced which when properly installed, completely answer the former objections of the underwriters. But it must be understood that the same laws and conditions which have made the metallic pipes of fixtures a source of difficulty, apply to any poorer conductor, such as damp wood-work, stone or brick walls, as well as crossing wires, water and drain pipes and the like, and demand that special forms of insulating material, preferably non-combustible, shall be employed, and particularly that in moist localities all electric light or power conductors shall be, so far as possible, aerially suspended so as not to depend too much upon the primary wrapping or covering or else that they be confined within moisture proof conduits or wire-ways.

In a paper read before the Society of Arts, Boston, April 13, 1893, by Captain William Brophy, who has long been recognized as one of the most conservative and intelligent insurance inspectors in this country, after referring to the slow growth of the telegraph and telephone systems of conductors and the occupation of the streets by pole lines and wires, the speaker considered the presence of overhead wires in streets as affecting the action of firemen in times of exposure.

"With this enormous increase of electric wires, the delays to the fire department became more frequent and losses by fire were often greater than need be, due to this cause; yet they did not endanger the lives of the firemen to any great extent, and were handled without fear.

"Later came that new form of electric energy—the electric arc light. Gradually it worked its way into public favor and gradually its power for mischief to the fire underwriters and owners of property became manifest by reaching the pockets of both. This was inevitable owing to the first crude methods resorted to for the transmission of this new form of energy. The existing forms of insulation were not equal to the task of confining this greatly increased force within bounds.

* * * * * * *

"With the introduction of this class of wires came another obstruction to the efforts of the firemen in extinguishing and preventing the spread of fires, and also a certain amount of demoralization in their ranks. Men who would face the flames, inhale poisonous gases, and stand beneath tottering walls without flinching, stood in wholesome dread of the arc light wires. The former elements of danger they were familiar with and could to some extent avoid them, while the latter contained hidden and to them mysterious dangers that they knew very little of. To handle such wires or come in contact with them meant injury or death. In addition to this they soon learned that the wires they had been accustomed to handle with impunity and remove when they became an obstruction, were liable to become dangerous also, and as a matter of fact firemen are justified in refusing to handle electric wires in towns or cities where an arc light plant is installed, unless during the hours when it is not in operation.

"Next in order came the incandescent electric light, direct or low tension system. While the wires for this system proved another obstruction,

they were not dangerous to life and limb; yet firemen, who are not expert electricians, looked upon them with mistrust. Later still came the electric power circuits. At first no greater than the usual 110 volt current was used, which is not dangerous to human life. Later this was increased to 220 in order to reduce the cost of conducting wire.

"Next came the transformer system of electric lighting, where a current of 1,000 to 2,000 volts is used in the primary conductors from dynamo to transformers. These were another obstruction and dangerous to the person.

"About the same time came the electric street railroads with their trolley wires, feeders, span and guard wires. That these prove a serious obstruction at fires no sane man can deny. They are also a source of danger to the firemen and contact with them is studiously avoided by those brave guardians of our life and properties."

IN WHAT DO THE FIRE HAZARDS OF ELECTRIC LIGHT AND POWER SYSTEMS CONSIST?

I trust that it will be noted that in answering this question, as well as in discussing other divisions of this broad subject, I speak from the standpoint of American Engineers, that is, I refer especially to those difficulties which have been developed in constructing systems in accordance with methods which have found favor in the United States.

While therefore, the general possibilities of difficulty apply to systems of similar character everywhere, the points to which special attention is now directed are among those which form the living issues in this country. To these I trust that in the discussion which this subject arouses, may be added any others which have commanded attention elsewhere, possibly in advance of their recognition here, perhaps because of the existence of different conditions or modes of operation from those which confront the American constructor. The possible hazards are few and easily remembered:

1. Poor regulation of dynamos.
2. Poor arrangement of translators.
3. Poor conductors.
4. Poor insulation.

These may be profitably considered more in detail:

1. *Poor regulation of the dynamo is a departure from the pressure or difference of potential required under varying conditions by the translating devices.* The securing of proper pressure is good regulation, because under normal conditions this pressure is expended, at the rate (per unit of resistance or counter electro-motive force) for which lamps or motors are designed. Where such translating devices are connected in series, good regulation consists in so varying the pressure as to maintain the current constant; where they are arranged in multiple arc, good regulation demands that the pressure shall be constant and so long as this constant delivery is maintained at the terminals of the devices to be supplied, no further attention is necessary at the source of energy.

In each case abnormal increase of potential results in abnormal current and this may set on fire the coils of arc lamps, explode incandescent lamps, and unduly heat the conductors of all parts of the circuit. The construction

of automatic regulators to maintain constant current in series circuits and constant potential in multiple arc circuits, has within recent years minimized this difficulty.

2. *An improper arrangement or placing of arc lamps, incandescent lamps or motors.* This may result in the ignition of surrounding combustible material, by sparks and the falling of hot carbon from arc lamps during their period of service, or by the direct action of the confined heat of incandescent lamps, or by the over-loading of motors, resulting in the reduction of the counter-pressure which they develop, and consequently in an increase of the current flowing through their mechanism up to the point of heating their coils and armatures. These are now uncommon sources of danger.

With the improved automatic cut-outs of the best arc lamps, by which the current is switched around instead of being allowed to pass through them, whenever it rises in a dangerous degree above the normal standard, or whenever the arc becomes so long as to place surrounding substances in danger; with spark arresters above and wire nettings around their globes when placed over inflammable material, there is little trouble. It is popularly supposed that an incandescent lamp cannot possibly radiate heat enough to set on fire surrounding substances, and show windows often display delicate lace fabrics in close contact with such lamps. This is simply taking unwarrantable chances, for it is merely a question of confinement and accumulation of the small heat, and the degree of readiness with which any given material will ignite. Colored and smoked lamps become much hotter than clear ones, and when the vacuum has become impaired, the conduction from the hot carbon filament across the intervening space to the bulb, is so rapid that the filament can hardly be forced up to its proper candle-power and the globe may become a source of danger, if in contact even with wood work. Safety to motors is secured by proper fuses.

3. *By poor conductors*, I mean such as are from any cause insufficient to maintain practical continuity at all parts of the circuit, and by "practical continuity," I mean to be understood, such a condition of the conducting material as to allow of the transmission of electric energy without danger. The necessity of such perfect continuity between the dynamo and the translating devices was recognized very early in practical electric light and power construction.

There are three conditions under which difficulties of this sort are particularly liable to arise, and all of them are of especial interest to insurance men:

(a). By commutators of motors or switches forming part of resistance devices or regulators. There have lately come to light several cases showing a trouble which will doubless soon be satisfactorily corrected, in the sparking which sometimes occurs when the circuit of an elevator motor is broken by the switch operated by the attendant at a distance. Under all circumstances where similar conditions are found, there is need of special protection, and this is occasionally true of other forms of switches by which such circuits are voluntarily closed or broken.

(b). By safety fuses, which may be called the automatic switches by means of which, without deliberate action on the part of anybody, the circuit is opened either as the result of the gradual melting of the fusible

conductor in the case of an over-load, or by the instantaneous and disruptive action which occurs at the same point in case of a short-circuit. When these devices were first practically used with pressures of 100 volts or thereabouts, no difficulty was anticipated excepting that the falling of molten globules of the fusible material might set fire to imflammable substances. It is not considered necessary to support such fusibles upon bases impervious to moisture or incombustible, but it has proved that such bases were essential, particularly with pressures like those of ordinary electric railway systems, where the melting of the fuse sometimes produced an arc between the terminals which remained, and that this arc would, unless these terminals were separated from each other by sufficient distance, destroy the terminals and set fire to surrounding or supporting material. It is only within very recent times that engineers have appreciated the explosive action which accompanies a short-circuit, and the necessity of placing the fuses which constitute the weak links in the chain of conduction, so that in case these links break by reason of any abnormal current, the result of their rupture in an almost infinitely minute interval of time may not injure their surroundings.

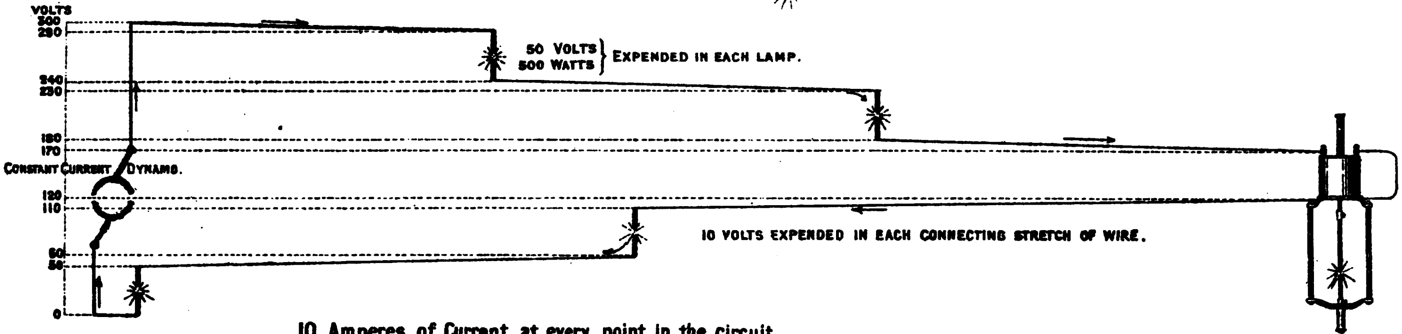
(c). Arcs occasioned by poor joints, accidental breaks or over-heating. It sometimes happens that a conductor may become, for the practical purpose of carrying the current which it is expected to transmit, entirely severed, although in such instances its ends may not be pulled apart to a sufficient distance to prevent the flow from taking place. Such an accident may arise from an obscure fault in the wire itself, injury from the tools of mechanics who may interfere with the conductors after they are placed, and other causes. Sometimes a brittle wire will break inside the insulating covering, or its carrying capacity will be so much reduced by cracking that heat will be occasioned at that point, the moment any considerable current is applied. In other cases, joints having imperfect contact with binding screws, or a small surface of contact with such screws or between ends spliced together, may occasion so high a resistance that heat may be developed and the metal become melted. Any one of these causes may be sufficient to produce an arc in series with lamps or motors, and such a danger has been found to be of the most serious character because it does not increase but ordinarily decreases the flow of current through the circuit and consequently does not operate to melt any safety fuses and thus automatically remedy itself. In case of an occurrence of this sort in a series circuit, the resistance of the arc is added to the resistance of the conductor and lamps, and the dynamo strives by reason of its construction to maintain a constant current, even though that current be relatively small. Such a case is illustrated in "Diagram 8—Series Arc Lamp Circuit." Here an abnormal resistance is shown to increase the potential generated by the dynamo and cause an expenditure of the electrical energy at the point of break which may be sufficient to start a fire, more particularly because, as illustrated in Figure 2 of this diagram, 1000 watts or nearly 1½ horse-power is expended in the form of an arc, nearly double the energy required for a 2000 candle power arc lamp, and producing the most intense heat which man has thus far been able to secure.

In a constant potential circuit the heating of an imperfect joint may, if

DIAGRAM 8.

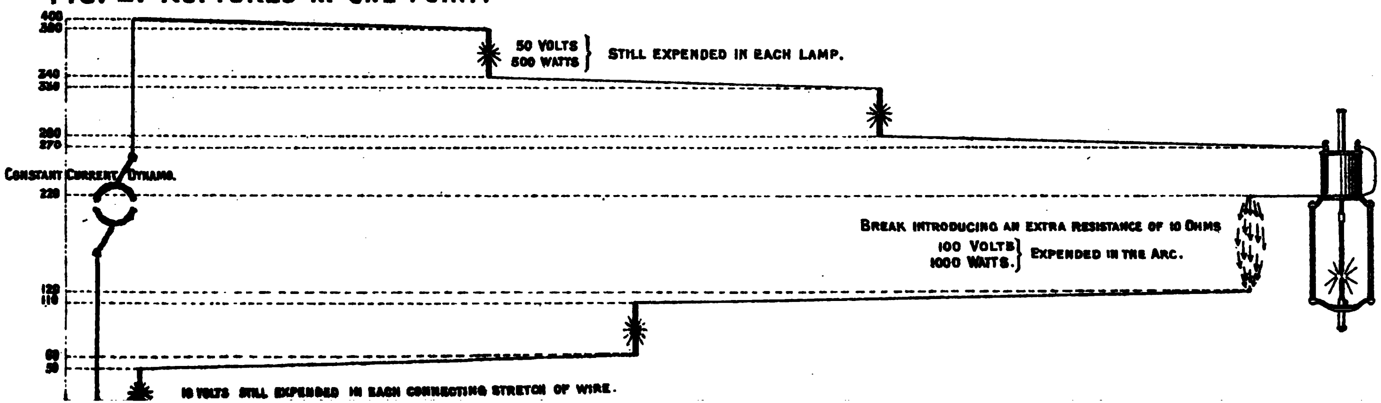
SERIES ARC LAMP CIRCUIT.

FIG. I. NORMAL OPERATION.



10 Amperes of Current at every point in the circuit

FIG. 2. RUPTURED AT ONE POINT.



it can affect a conductor of opposite polarity, as for instance, when positive and negative wires are close together, call a large amount of energy to a single point, as in the cases we have already considered in connection with fixtures. With a pressure of several hundred volts, as in electric railway construction, the arc may prove a serious matter even if a short circuit is not produced. Happily instances of this variety are not common.

The over-heating of conductors from currents too great for them to trsnsmit when so incased as to prevent easy radiation, or from any other cause, was one of the earliest difficulties recognized by both insurance men and electrical engineers, as is clearly evidenced by the foregoing extracts from expressions of solicitude on the part of the Underwriters. This is avoided by proportioning the size of the wire to the amperes it must conduct and this method is effective in both series and multiple arc circuits, the former being adapted in the mass or gross section of the wires for the amperes which are to be constantly expected, the latter for the maximum expected.

It is interesting to note that the tables of "safe carrying capacity" which have now for several years been made a part of the best rules for constructors, have lately been objected to on the ground that there is in them a larger margin of safety than is necessary in practice. To quote the expression of a recent statement of the case by one of the best engineers now in the electric light and power field:

"The table showing safe carrying capacity of conductors is, I think, entirely too rigid. Fully sixty per cent. more current can be safely carried than shown in table, and at least forty per cent. more could be allowed with just as much safety as the amounts indicated in the table. This table necessitates the use of very large wires where the distance is short and the number of lights considerable."

On the same point, another intelligent engineer says:

"I think the capacities of wires given in the present rules of the underwriters are too low; they correspond to a rise of temperature less than 30 degrees F. They could be increased 50 per cent. without the possibility of danger. These narrow limits of admissible current often seriously increase the expense of obtaining a uniform distribution of potential."

Some time ago I thought it wise, in view of the great importance of this matter of safe carrying capacity to the question of security from fire hazards, to request of Prof. A. E. Kennelly, electrician at the Edison laboratory, an opinion as to whether the margin of safety established by The National Code of insurance rules was from a theoretical standpoint unnecessarily large. Mr. Kennelly's judgment in matters of this kind is entitled to great weight in view of his numerous exhaustive experiments in many directions, and particularly because of his work in 1889 summarized in his paper on "Heating Conductors by Electric Currents" read at the Niagara Falls meeting of the Association of Edison Illuminating Companies, August 13th of that year. This paper was at the time circulated in pamphlet form, widely reproduced by the electrical journals and has become a classic in this field. Professor Kennelly replied, under date of January 11th, 1893, as follows:

"The table of safe currents given on page 7 of The National Code is in practical agreement with the table of safe currents appearing on page 10 of my report upon the heating of conductors. The definition in the Code of what constitutes the safe carrying capacity of a wire, I must, however, disclaim. In fact I never ventured to express an opinion as to what was, or should be stated as, the safe carrying capacity of a conductor. The duty I endeavored to accomplish was to ascertain experimentally what temperature elevation could be produced in a given size of conductor by a specified current strength uniformly maintained through it. Having given the results, I looked for existing definitions of safe carrying capacity, and found that recommended by the committee of the Institution of Electrical Engineers (London) 'On fire risks in electric lighting,' as mentioned on page 8 of my report, and the table on page 10 merely translates that recommended rule into actual wires and currents.

"The rule means that the temperature elevation of the wire under load is practically 10 degrees C. or 18 degrees F. above surrounding bodies. Just what reasons the committee had for recommending that rule we cannot say, but it certainly seems very safe—unnecessarily safe probably, and I have always believed that this measure would in time be amended. The data supplied by the report submitted to you enable a scale of sizes to be established for any temperature elevation that may be fixed upon.

"I have just found that the physiological definition of safe carrying capacity on page 7 in the National Code, means in my own case a temperature attained of just about 50 degrees C.

"Taking the normal temperature of wires as 24 degrees C. on the average, this would mean a full load elevation of 26 degrees C., say 25 degrees, or 2½ times as much elevation as the National Code table allows, representing an increase in all the currents of roughly 55 per cent. In my opinion that would be still a safe temperature. Yours very faithfully,

A. E. KENNELLY."

I have also thought it important to secure the views of practical central station electricians from the standpoint of companies which must constantly consider the peculiar conditions which arise in distributing and selling electrical energy to the public.

One competent central station inspector, after reading the statements of the two engineers already quoted, makes the following reply:

"From the Illuminating Company's point of view, we believe permission on the part of the Underwriters for a decrease of size in the conductors for the interior wiring of buildings would be very undesirable for the following reasons: We find it to be almost universally the case that after the wiring is installed for a certain number of lamps of a certain candle power, the candle power is increased, thus demanding double the amount of current. In addition to this, it is generally the case that the number of lamps is also increased, so that the copper, instead of being too heavy, as it was for the original installation, is entirely inadequate to carry the amount of current necessary to supply the final installation. No doubt the size of the wires in the tables is a little large for the amount of current which it is figured to

carry, but as our experience tells us that in almost every instance the amount of this current is increased, we do not think it advisable to decrease the size of the wire. Even in cases where the wires can be readily pulled out when an increase becomes necessary, it seems doubtful whether it would be policy to cut down the amount of wire on account of the cost of labor in taking it out and putting it back again when it became necessary. Of course this latter is a question of judgment in each particular case. In case the contractors installing the wires do not get them in large enough, the Illuminating Company is held responsible for poor service and in many cases has to go to considerable expense in order to keep its service up to standard, so that, look at it in any way, it is to our interest to have the wires as large as possible."

As therefore in the engineering of important mechanical undertakings, a large percentage of margin of safety is and should be allowed, particularly where the exact maximum of future requirement cannot be predicted, it needs no further argument to demonstrate the soundness of the latter position, above quoted, in the field of electrical engineering. But a concise and unexpected method of expression which the student (we are all students in this electrical art) can carry away with him is ever welcome, and such is the following from the vigorous pen of one of the most widely known of municipal inspectors of electrical risks:

"I think the two engineers first quoted are both arguing rather from the standpoint of the investor-contractor than from that of the investor-owner. In other words they make it a question of dollars versus safety.

"In this city the smallest wire in use is No. 14 B. & S. except in cords or single lights with very short runs. Reinspection is daily exemplifying the wisdom of an ample carrying capacity in all conductors. I can give you two instances which occur to me just now.

"(1). A show-house which had some 9 amperes on a wire (foot-lights) was encouraged by a drumming salesman to double the ampere flow by substituting 32 c. p. for 16 c. p. lamps, and the 'electrician' told the writer he didn't think it was anything out of the way. Only reinspection brought the fact to the surface.

"(2). In an office building here the all-wise 'electrician' of the plant added a circuit of No. 16 wire substituting 32 c. p. for 16 c. p. until he had 36 lamps, and the fact only leaked out through the want of more light, requiring an overhauling of the plant.

"The necessity for more lamps on a circuit in an office building which is liable to change its tenants every year, and to change desk locations any time, must be watched and provided for I think. Once the plant is installed it goes out of the company's hands, and the electrical butcher who is placed in charge usually doesn't know enough to make a safe joint, and sees no reason why he cannot add lamps ad infinitum on any wire regardless of size.

"Another reason for requiring large wire lies in the fact that the plant installed for Mr. A. was originally a 110 volt 0.5 ampere outfit, and ten lamps were placed, we will say, on a No. 16 B. & S. conductor. The plant for some reason is changed to a 50 volt 1 ampere system; it is true that the converter may be changed to correspond, but it seldom is unless at the

order of some authority, and unless there is some such interference, 10 amperes will traverse the wire which was originally run for but 5 amperes. (5 amperes is our rule for an ultimate cut-out).

"Now experience has given us here plenty of instances in central station work similar to the above. There is a close competition in the center of the city between the alternating and the direct current systems. The patronage is constantly shifting; today it is Edison, tomorrow Westinghouse or Slattery, and we are kept busy watching for results which a sufficiently large wire and a minimum current flow would amply protect against. We are compelling reinforcement of conductors constantly.

"You may think me prolix, but I feel almost nervous at times over this carrying-capacity business when I find persons in charge of installations who are ignorant of the first principles of the science; men who think they are doing good service if they can fool an inspector and thus run the chance of burning a building; hired because they work cheap, and kept because they are time-servers and braggarts. So you will, I trust, excuse me for giving vent to my feelings in this manner."

(4). *A departure from absolute practical insulation of the entire generating, conducting and translating systems.* If the integrity of the insulation of the dynamo and conducting wires and the lamps or motors can be depended upon, the largest number of possible difficulties will disappear. During the early years of practical electric lighting and power transmission, before experience had given confidence to investors, a prime necessity to the growth of the business was that plants should be inexpensive, and cheap methods of covering and supporting all parts of the circuit were devised and generally adopted. Experience has shown that this does not save money, and that in the long run, the owner, the user, the operator and the insurer of an electric plant will find it to their advantage to combine in requiring the constructor to put in the best material and apply the best methods which present knowledge provides. After the failure of the first electric light insulating covering which has been alluded to as "Underwriters Wire," a reaction occurred and coverings which secured the highest degrees of insulation, consisting of various forms of rubber, were devised in considerable variety. It has required the test of several years to show that none of these forms of practically moisture proof insulation are likely, if unaided by co-operative "supplemental insulation" of glass or porcelain or similar rigid material, to stand the test of time. This subject is an exceedingly fruitful one and might well form by itself the topic of another paper. It may be summarized by saying that at the present day, experience dictates that in the interior wiring of buildings where conductors are permanently covered so as to be beyond ready inspection, they should be so placed and supported that if their insulating wrapping were to entirely disappear they would still be safe in the view of the insurance underwriters. Among other ways in which this desirable result may be obtained, two are worthy of special mention, because they are within the reach of every constructor and one or the other may be applied in every case.

(a) The support of conductors at a proper distance from each other and from conducting material by moisture-proof non-combustible insulation, such as glass or porcelain. The introduction of such material in the

manufacture of switch bases, fuse blocks, socket insulation, cleats and knobs, marks an epoch in the business of distributing powerful electric currents. Taken in connection with the use of fire-proof frames for resistance coils and small devices, it is one of the greatest practical advances made within the past ten years in this field. The high insulation obtained by the use of glass or porcelain sometimes causes an accumulation of finely sub-divided particles of lint or dust upon the electrified wires. Such conductors in some manufacturing establishments, if not regularly cleaned, become channels for the spread of fire, and should be considered in any inspection of risks of this class.

(b) The enclosure of well insulated conductors in conduits or wireways. The present rules of the underwriters set forth that the "object of a tube or conduit" for interior wiring "is to facilitate the insertion or extraction of the conductors, to protect them from mechanical injury, and as far as possible from moisture." It is a serious question for the insurance inspector to determine whether there is any method now practiced which secures these results, or whether there is any system or form of construction now in general use in which the tubes do not contain within themselves the elements of their own destruction. It is evident that if conductors are to be capable of ready removal for inspection or replacement, they must be so well insulated from each other and from the tube with which they may be surrounded as to resist the tendency to leakage or short circuit which is produced by the pressure of the particular system to which they are to be applied. Frequent difficulties arise from the disturbance of such tubes by carpenters, masons, gas-fitters and other mechanics who make changes in the surroundings after the tubes have been placed. Is there not a suggestion of a cheap and useful form of conduit for this work, in the fact that for ten years or more the metal pipes of fixtures carrying electric lamps have supported and mechanically protected the wires by which these lamps have been fed?

We have only to consider how the portion of the interior conducting system which can be removably enclosed and protected can be extended from the short length which we now place within the fixture pipes, to the entire length from the lamps back to the service (or junction of the interior conductors with underground or overhead distributing wires) for which extensions of these fixture pipes from the ceiling outlet to the point of supply of the building would provide. Can it not be presumed that if by closing the upper end of the fixture stem with a water-tight plug we have been able for the past ten years to keep the enclosed wires running through that pipe in good condition, so that they have neither short-circuited between themselves nor grounded upon the fixture metal, we can make an entire system of distributing tubes of gas pipe without encountering serious engineering difficulties? For such a purpose it may be found desirable to use a separate tube for each wire or polarity, particularly in a case of those conductors which carry current for many lamps, but it seems probable also that with concentric conductors having one polarity forming a core and the other wound in a long spiral around it, and separated by carbonizable material (and not by rubber and similar moisture-proof material) the twin conductor thus formed being covered with such insulation as to be imper-

vious to moisture, we should have a cheap and at the same time reliable variety of wire. Assuming that the lengths of piping might be joined by non-conducting unions so that a ground connection on one length would not affect others in the same line, and that in this way the electrical strain which ordinarily exists between the outside conductor and the pipe would in this system be practically absent, we should have no tendency to leakage except from the outside to the inside conductor through the carbonizable insulation.

If by any means this insulation should fail, the reduction of it to carbon would insure an arc of very low resistance amounting practically to an absolute short circuit, which would also be assisted by the enclosure of the generated gas within the surrounding iron pipe. Under these circumstances the immediate fusion of a suitable safety wire would be a certainty, and thus any possible difficulty would be confined to a single line of such a tube. If this suggestion be not, in all its detail, entirely feasible at this moment, may it not be so worked out as to become so?

These ideas are not original with the writer of the present paper. They have long been advocated by some engineers who were very early skilled in the incandescent electric lighting art, among others the well-known Consulting Electrical Engineer of the World's Columbian Exposition, Mr. L. Stieringer, to whose practical inventive genius and large experience in illumination by other agents, the present success of the lighting of the Manufacturers' Building by coronas, the beauty of the electrical fountains and other features of the Fair are due. In the Electrical Engineer of June 8, 1892, Mr. Freemont Wilson, a well-known inspector of New York, made the following vigorous expression:

"Two and a half years ago the writer was asked for an opinion in regard to interior conduits, and to the surprise of the party asking the question, he said: 'Interior conduits to be successful must be able to stand the action of all kinds of alkali in plasters, and must be absolutely proof against the tools of mechanics, and, furthermore, absolutely water-proof and fire-proof, and *must not* be relied upon for *insulation, the only place for insulation being upon the conductors themselves*.' The question was then asked: 'Why, then, do the New England Underwriters insist upon the use of conduits, and furthermore, allow the use of such cheap grades of wire?' The reply was, that any party or parties who recommended any conduit then on the market, or demanded its use, and allowed twin conductors with cotton insulation, was either ignorant of the entire subject or was interested; for the only conduit that was needed was that used by the gas man, viz., iron pipe, to be made and installed under certain specifications. The writer also had the word of one of the largest pipe makers that a first-class article of piping with right and left threads could be placed on the market at the same price as gas pipe and perhaps cheaper; but the trouble with this system was simply that it could not be patented, and therefore, underwriters, architects, and owners of buildings must be kept in blissful ignorance of the safety and feasibility of iron conduits so as to enable conduit people to line their pockets with the money of the poor public.

"For this answer the writer was severely criticised by certain parties, but, nevertheless, time has proved that the remarks were correct, inasmuch,

as, at the convention held at Buffalo in February, of this year, Capt. Brophy, formerly of the Boston Insurance Exchange, was forced to admit that the conduits used were a failure."

"The writer over two years ago installed in New York an installation of over 3,000 lamps, and all the primary feeders connecting the various converters were placed in gas pipes. The pipes were laid on the iron ledges of the building and white core taped wire used; and, although these pipes and wires of a total length of about two miles were placed in position by inexperienced men, yet they have been in constant successful use for eighteen months, conveying a current of 15 amperes and 1,000 volts, constantly exposed to the weather; and yet we hear that it can't be done—that to install iron pipes and pull in wires for use at 50 or 100 volts pressure would be suicidal. Is not every combination gas fixture an example of conduits?"

"That the conduit people have seen their blunder is only too evident as we all know, from the fact of their covering their present material with metal; but let us hope that before long the underwriters will not only *allow*, but *insist* on, solid metal conduits specially built and installed in all classes of concealed work, and then, and not till then, will this everlasting hue and cry about electric light fires cease."

"The New Orleans Underwriters have just adopted a stringent rule in regard to conduits, but they are simply recommending a special conduit, although it does not show on the face of their order, and they will go through the same experience, only in a less degree, that the Boston Underwriters have passed through. There is, in the writer's judgment but one conduit; and let us learn a lesson from our enemy the gas man, and use it—the iron one. I may add that the Chicago Underwriters have recently stated that they are in favor of iron conduits; and the question must soon be faced by all concerned."

At the close of his Cornell University lecture, from which quotations are elsewhere made, Mr. C. J. H. Woodbury states some plain facts bearing upon the perishable character of the insulating coverings and conduits used in the wiring of buildings, as follows:

"The status of uses of electricity for illumination and power is so well established upon a practical basis, as regards the service to be expected and the character of the attendance required, that there is but little of a tentative or experimental nature in such work, and there is therefore no excuse for the continuance of many of the temporary methods of installation which have been in such general use."

"One of the pernicious results liable to occur as a consequence of such methods of installation is the depreciation of such apparatus—from which I apprehend that difficulties may arise in future."

In the Journal of the (London) Society of Arts of May 5, 1893, appears this concise and forcible statement, more telling than any words of mine, because from the pen of Prof. Silvanus P. Thompson, universally recognized as one of the most forcible and reliable of electrical writers:

"In house-wiring, too, practice differs. The wooden casing that, thanks to the fire-office rules, is almost universal in England, is by no means universal elsewhere, and, in some countries, is almost unknown. It is probably destined to disappear in time, when safer modes of carrying wires

are recognized. Wood-casing has three grave defects—it is neither damp-proof nor incombustible, and, too often, it covers, like charity, a multitude of sins. In this connection it is important to note that, in spite of the curious predilection of so many of our fire-offices toward the use of wood-casing, the proportion of electrically-caused fires in this country is extremely low. This satisfactory circumstance must be attributed, not to the general use of wood-casing for house-wires, but rather to the very wholesome dread inspired by the vigilant and able surveyors of the chief fire-offices, of whom Mr. Musgrave Heaphy is the most eminent, and who have, in spite of the curses so frequently showered upon their heads, insisted upon the prime requisites of good material and sound workmanship in all risks that they undertake to insure. If their requirements have seemed, in individual cases, hard or arbitrary, they have done incalculable good in stamping out the inferior work of scamping contractors. It is an open secret that some of the New York fire-offices have become of late very uneasy about the increasing prevalence of electrically-caused fires. It is even stated, though I cannot name my authority for the information, that some of them have recently sent representatives to this country to learn how we manage to keep electric lighting safe. Doubtless we shall, at Chicago, exchange opinions on many of the details of this highly practical question. What is wanted is a mode of running the wires and fixing the switches and other accessories that shall not only be electric-tight, but shall also be water-tight, gas-tight, air-tight, oil-tight, fire-tight, and rat-tight."

In connection with the subject of the opinions of the electrical and insurance authorities of Europe and the practices which they there approve, an interesting statement is made by Mr. William McDevitt, Electrical expert of the Philadelphia Fire Underwriters association and the Philadelphia Fire Patrol. Mr. McDevitt has long been recognized as the guardian of good practices in electric wiring in a large territory south and west of New York City, and in the early part of the present year made a visit to Europe to examine from the underwriters' standpoint into the methods of wiring and general electrical operation there employed. His report says, among other things:

"There does not appear to be any uniform system of installation rules in Europe; one prominent company issues a code of rules for its own protection, but each insurance company makes inspections for itself."

"I see no radical difference between the interior wiring in the cities visited and our own. Interior conduit work, concealed work, moulded work and surface work is used as much as it is in this country and in about the same proportion. In making comparison, therefore, I think I can save time by simply considering only the points where we differ."

* * * * * *

"The second great difference is that they trust throughout to the insulation on the wires. We on the contrary, do not trust to the insulation alone, but also upon the way the wiring is done. They use only one or two kinds of insulation (practically), all of the best quality of rubber. The question

as to which is the best, to trust to the covering on the wire alone or to proper installation, is an open one."

* * * * * *

"After all has been said, the report that they do not have any fires or accidents from electric light wiring in Europe comes from those who are ignorant of what occurs. I called upon several insurance companies and endeavored to get from them some information as to the general results from the use of electricity, but found that there were no such electrical bureaus as are attached to our Fire Underwriters associations. Each company could only tell me of the electric fires which had occurred among its own risks. In one large insurance building visited, where electric lights were used, my opinion was asked regarding the installation which appeared to be very good, yet it was admitted that two fires had occurred from the wiring."

"When interviewing the electric light contractors, I found that they were all very willing to talk and relate occurrences of electric fires and curious freaks of the electric current, and at the same time exhibit specimens of dangerous electric defects developed in buildings where electric lights are used. These interviews seem to prove that they have experienced as much trouble as we have had, and in comparing the size of the installation, probably just as many little accidents and fires if the investigation of electric dangers was followed and watched as closely as with us. I concluded from the talks with various superintendents and contractors that in comparing results we are all pretty much on a level."

PRACTICAL QUESTIONS OF TO-DAY.

Interference between independent systems. There are several features of electric light and power construction as at present conducted which have occasioned much discussion between the electrical engineers and the underwriters, not only because of the questions which arise as to the safety from fire of the electric light and power systems themselves, but also as related to other systems with which in crowded communities they are likely to come in contact. It is evident that if absolute immunity from disturbance of one system by the action of another is to be secured, it must be accomplished in one of three ways.

(1) By preventing the two systems from establishing any electrical contact whatever between their circuits. This can be done only by using complete metallic outgoing and returning conductors and maintaining the insulation of each practically perfect.

(2) By the use of a metallic conductor common to both circuits through a portion of its length and of so low a resistance as to occasion practically no loss of pressure in the current of either system, and thus to have no difference of potential between the ends of the common section under any circumstances.

(3) By using the earth as a common return for two systems which are capable of operation when so connected without mutual interference, at

least to a degree which will allow of no abnormal or dangerous flow in either one in consequence of its electrical connection with the other.

(a) Three Wire System. There are two classes of plants to which the above remarks specially apply. One of these is the Edison three-wire or compensating system of incandescent lighting, having its middle or neutral conductor grounded. In order to illustrate the points I wish to make, I have prepared "Diagram 9,—Three Wire System with Grounded Neutral Conductor." A considerable number of central station plants in the United States, and I am informed in other countries, have been operated for several years with the neutral conductor more or less constantly grounded. It has been alleged that such systems offer an extra hazard to the fire insurance people and should be prohibited, and in some cases illuminating companies operating large systems have been compelled to remove the grounds which have been established at various points throughout the district lighted, on penalty of the cancellation of policies covering the premises and property of their customers.

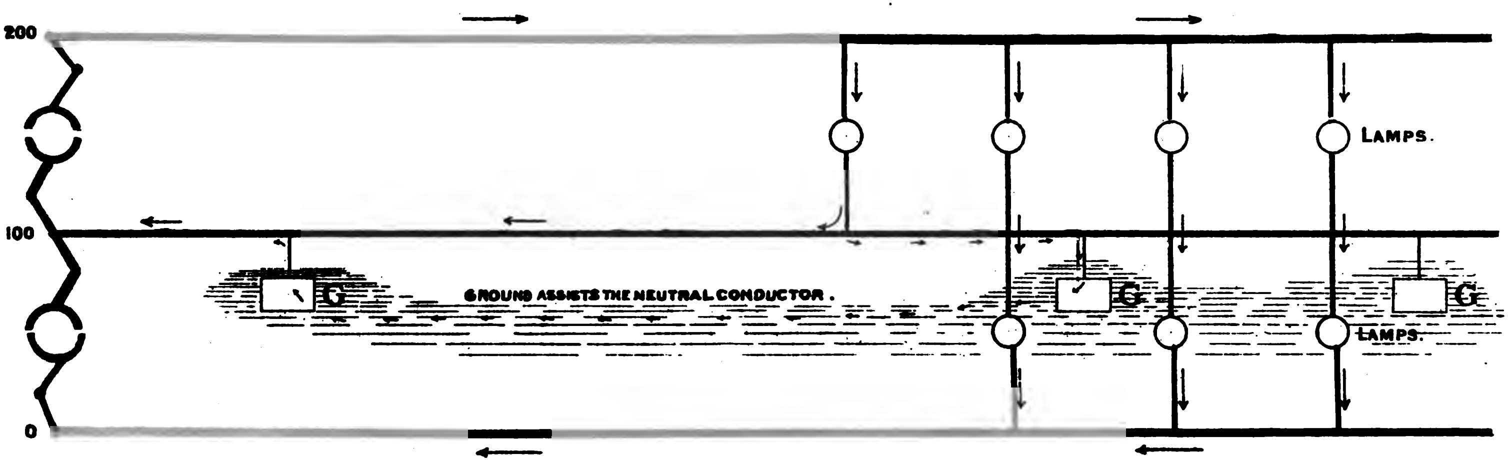
When a three-wire system is properly installed, the lights or motors are carefully divided, in each building of any size, between the two sides of the system, so that almost the entire current utilized in such a building passes in on the positive, through the two sets of lamps or motors in series, and out on the negative wire, there being never any great disparity between the two sides which would occasion much of a flow along the middle wire, either in or out of the building. This system of local balancing removes from the middle conductor of the street main the necessity of ever carrying any considerable current from one point to another of the district lighted, or between the lamps and the central station. Thus if the wire be grounded there is very little call upon the conductivity of the earth itself, more particularly for the reason that in such systems the neutral or compensating conductor is never dispensed with, although it may practically be made of smaller size than either the positive or negative. In case the earth's conductivity should be unreliable in consequence of varying degrees of moisture in the soil, or of the presence or absence of water pipe, gas pipe or other metallic conductors, or in consequence of peculiar geological formation (in which case the soil appears in some districts to be almost absolutely insulated from the great mass of the earth's body,) the middle conductor is always competent to carry all the current which is ever required to maintain a balance under practical working conditions.

It is my conviction that in many three-wire systems ground connections may be advantageously made along the length of the compensating conductor, and this without adding to the fire hazard, but rather with a reduction of the likelihood of danger. It should be regarded as an emergency plan and may be useful to the system of several cases or conditions which are of interest to the underwriters, in addition to several others which affect simply the convenience and reliability of operation of the system itself, and which consequently cannot be considered at this time. More specifically, I believe:

(1) That a three-wire system, if free from grounds and capable of being practically and commercially kept free from them, ought not to have

DIAGRAM 9.

THREE WIRE SYSTEM
WITH
GROUNDED NEUTRAL CONDUCTOR.



Balance closely maintained; only small difference of potential ever exists between two grounded points.

its neutral grounded; in other words its insulation should be maintained so that it will not come in contact with any other circuit at any point.

(2) That when such a system develops a ground at some point and the location and removal of such ground can be speedily carried out, it is better to effect such removal and keep the neutral wire insulated.

(3) That when grounds develop in an underground system with a frequency which does not allow of their independent search and removal, it is advantageous to ground the neutral temporarily in the station, in order to clean the grounds off if they occur on the outside conductors, or if on the neutral itself, to protect it from producing a short circuit in the tube by an arc, should an outside ground follow.

(4) That when the insulation of such a system becomes so much reduced that grounds can seldom be cleared for many hours together, it becomes advantageous to ground the neutral permanently, and when this step is finally taken, it is better to do the work thoroughly by grounding at every junction of a feeder with the mains, so that the resistance of the earth circuit in any direction may be as nearly as possible at zero.

(5) That in such a case there is a reduced fire risk, since a ground created inside a building, will if on the neutral conductor be no source of danger whatever, while if on an outside (positive or negative) conductor, it will probably fuse a safety catch, or do all the damage of which it is capable, at once, and not remain inactive until the appearance of a subsequent ground on the opposite side of the system at a time when no person may be at hand. In other words it will be a means of keeping one portion of the system at the same potential as the earth, and thus make it certain that in case a low resistance leak is developed at any time from one of the outside wires to a gas or water pipe, or other conductor leading to the earth, such leak may not be able to exist for any length of time because it will speedily develop into a short circuit with the middle conductor which is kept grounded, and immediately melt a safety fuse and cut off the leaky portion of the line. It sometimes happens that leaks of this kind develop during the night in unoccupied buildings. In such a case the throwing on of a switch next day causes the development of the presence of the leak at a time when there is less danger from an accidental fire.

(6) That in any case there is also a reduction of the fire risk resulting from the limitation of the electrical pressure capable of causing damage by reason of the occurrence of any ground connection to 100 or 120 volts, whereas the active pressure might otherwise be 200 or 240 volts. Thus in Diagram 9, as the earth is intimately connected with the middle conductor which has a pressure of 100, the difference between that pressure and that of the positive or that of the negative wire cannot be more than 100, whereas without the grounded middle conductor if the negative wire were connected to ground by a leakage, the positive would be 200 volts higher in potential than the earth, and vice versa. It has been fully explained in connection with Diagram 1 that where the potential of the earth is half way between that of two conducting wires, the pressure tending to break down the insulation of each of them at any point where the earth or its connections may come in contact with the wire is only one-half as great, and the actual amount of energy expended in the endeavor to overcome the insulation of either of

these wires is only one-quarter as great, as in a case where the other wire was grounded. Perhaps the most important of the advantages to which I have referred is diminution of the difference of potential to earth which perpetually tends to develop leakages through the insulation of underground conductors or that of the interior wiring of buildings, or both. This advantage may be well expressed by saying that grounding of the neutral conductor maintains constant that normal difference of potential between the active outside wires of the system and the earth, which exists when their insulation is practically perfect. As experience brings out improved methods of securing a high insulation in both underground and interior wiring, it becomes feasible to maintain this practical perfection of insulation without grounding the neutral, and thus this difficulty which grounding tends to mitigate is otherwise overcome.

(7) That in overhead circuits the grounded neutral gives greater immunity from the effects of lightning.

(8) That in small systems, or those of moderate size, it is a useful means of reinforcing the neutral conductor in case of reversal of the polarity of the dynamo or dynamos on one side. A reversal, which may be caused by lightning, by an unusually serious short circuiting, or by other causes, accidentally changes the condition of the compensating conductor from its normal state, in which it carries but a small current, and compels it to carry the entire current necessary to supply the lamps on both sides of the system. This increase may overheat the middle conductor, because the total current is under these circumstances twice as great (providing the lamps continue to burn at normal candle power) as the total current was before the reversal, and requires, in order that proper operation be maintained until the reversal can be discovered and remedied, at least four times as much conductivity in the middle conductor as before.

(9) That there is evidence derived from experience in large central stations showing that the plan of grounding the neutral under the conditons above described, has been a positive advantage, and that if coupled with the periodical testing of the insulation of interior wiring, which every central station should make as a matter of self-protection, all objection to it would disappear.

(10) That with the constant improvement in construction, in installation and in maintenance, even of the largest and most comprehensive underground multiple arc plants, where the difficulties of maintaining the combination of high insulation and uninterrupted service to all consumers reach their maximum, every year diminishes the necessity of grounding the neutral.

(b) Electric Street Railways. From the earliest experiment in this line it has been a favorite idea with railway constructors to economize in the cost of conductors for distribution, and simplifiy the problem of insulation, by using the earth as a return circuit. Such a system and its liabilities may be considered by assuming two cases outlined in Diagram 10, figures 1 and 2. The dynamo is assumed to maintain a constant potential difference of 500 volts, the positive terminal being connected to the trolley wire and the negative to the rails and the earth. It is assumed that there is a drop of 50 volts or 10 per cent., between the dynamo and the cars at maximum load,

DIAGRAM 10.

ELECTRIC RAILWAY CIRCUIT.

FIG. 1. NORMAL OPERATION.

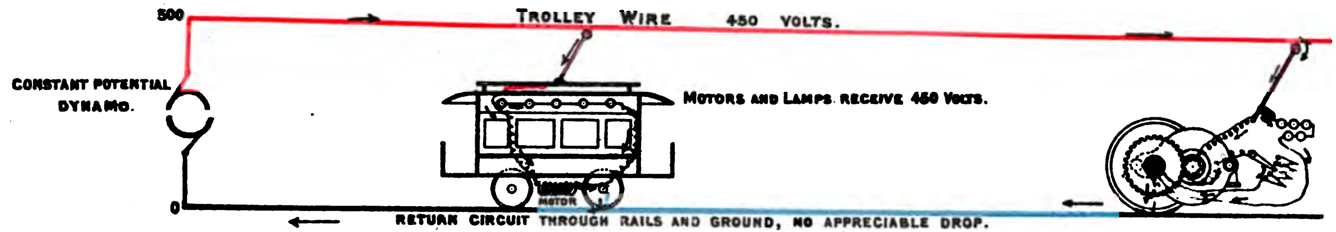
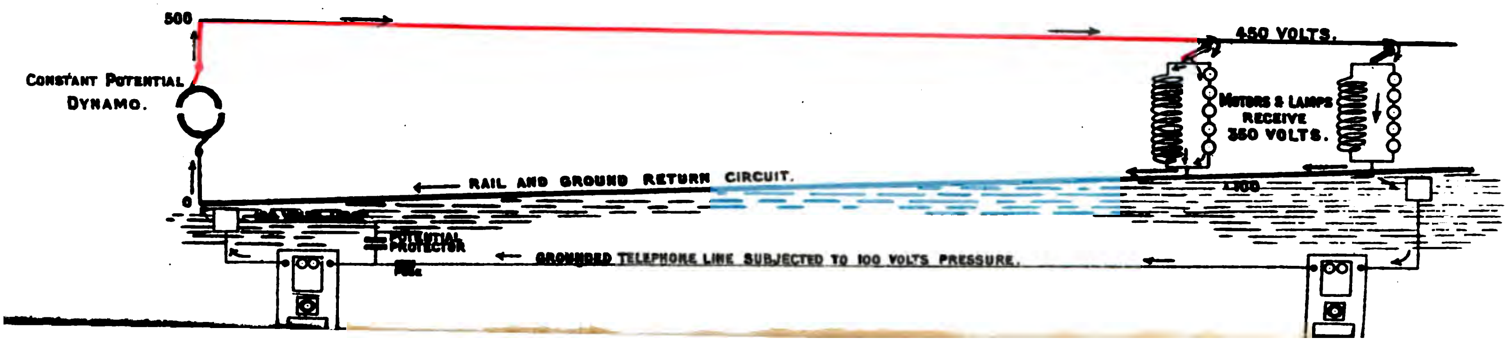


FIG. 2. ABNORMAL DROP IN GROUND AND RAIL RETURN.



and in the first case that the motors and lamps for lighting the cars receive the remaining 450 volts, the return being made without drop of an appreciable amount. In the second case it is supposed that the dynamo still maintains its 500 volts and the line still absorbs 50 volts, but that the drop in the ground and rails is increased from practically zero to 100 volts, thus leaving but 350 volts for the motors and lamps. Under such circumstances a telephone line grounded at one end near the dynamo and at the other end near the distant cars, will receive and transmit, if its carrying capacity allows, from the cars back to the dynamo through the instruments, a current due to the difference of potential between its ends, 100 volts. It may thus become a source of danger in the buildings through which it runs or to the instruments and their surroundings.

For a considerable time after the practical operation of electric railway plants commenced, such a state of things as is indicated in the second case was never realized, at least for any length of time, although it is remembered by the writer that one of the pioneers in electric railway work stated during his first experiences that he had found a drop of 45 volts to occur within as many feet at a point between the rails in the street and the ground plate to which one pole of the dynamo was attached. Subsequent improvements in electrically connecting in a more reliable manner the lengths of rails with each other, and by frequent plates and pipe connections with the earth, and still later by a copper wire placed between the rails and connected with them at frequent intervals and leading back to the dynamo, has distracted attention from this possible difficulty during the rapid development of the past three or four years until it is again forced upon the attention of the engineers and the underwriters in consequence of the enormous volumes of current which are carried on some single lines of street railways for the supply of the great multitude of cars. Where these cars are very heavy and of large capacity it not infrequently requires from 30 to 50 amperes for each motor during some periods of its regular trips or at some times in the day. At an average of 40 amperes, only 25 cars would be required to raise the volume of current to 1,000 amperes. When it is remembered that 1,000 amperes means simply that pressure is expended in the conductors at the rate of 1,000 volts in every ohm of their resistance, it will be evident that in such a case the inevitable length of the conductor, and the return circuit of rails, ground and wires must not only require a great amount of copper for the outgoing side of the system, but should also require a liberal investment in the return side, unless the resistance of the earth when reinforced by the rails falls exceedingly low, and it is found in practice that such is not the case, when judged by the standard of the requirements of the large currents demanded by many 25 to 30 horse-power motors in multiple arc.

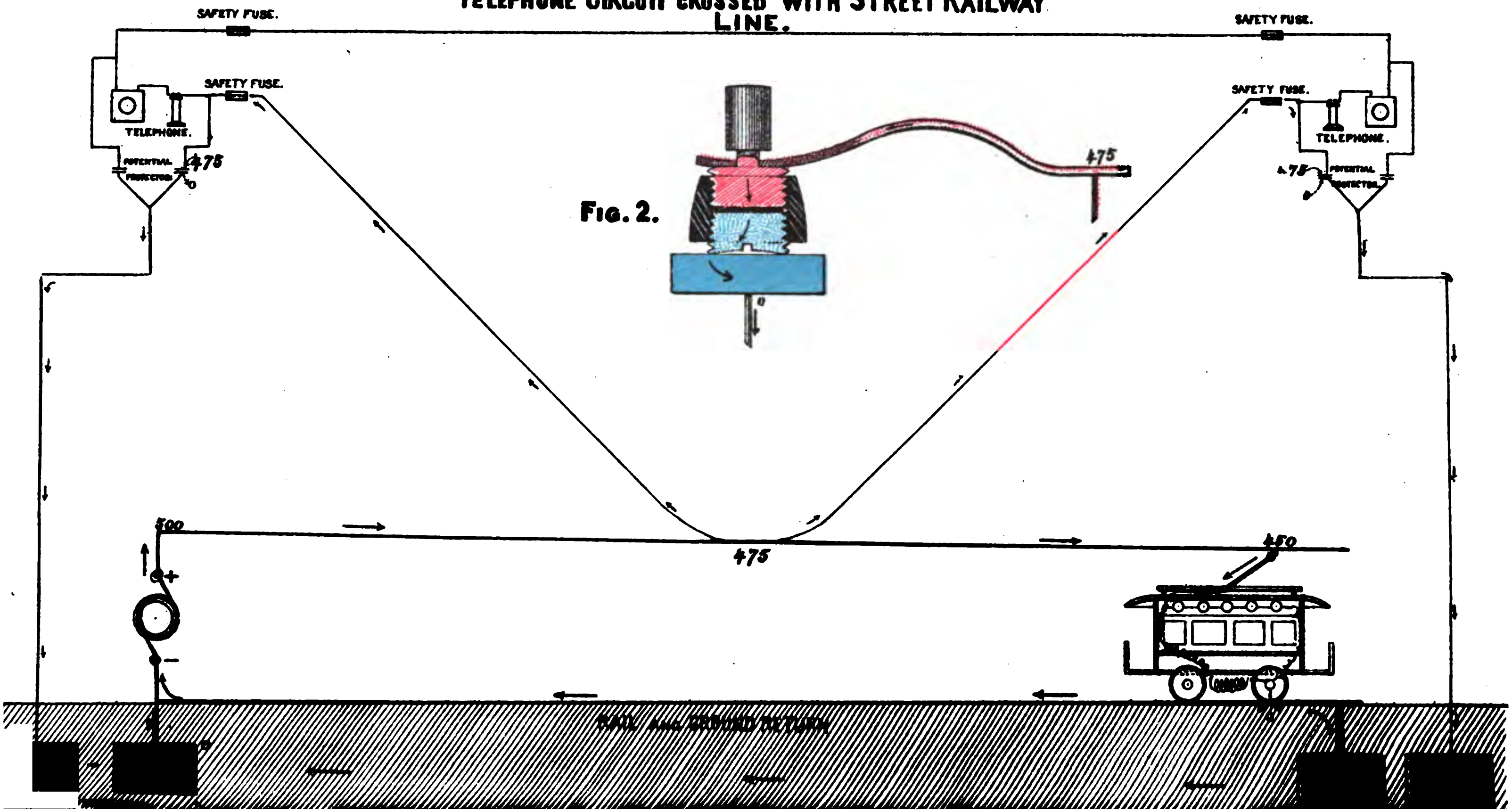
The time is coming when in order to assure themselves that electric railway circuits are not likely to interfere with the operation of otherwise harmless lines, so as to make such lines a source of danger to the buildings which they enter, the constructors of these railways must either lay down in the street or carry upon poles such a mass of copper as will make their installations metallic circuits of wire, whether they are as a matter of fact somewhat reinforced by the rails and the ground or not. This careful calculation of both sides of the multiple arc system will prove as valuable a

method to the railway interests as to the underwriters, not only because it will lift their plants above reproach, but will make it easy for them to properly proportion the energy, which is unavoidably wasted in transmission between the dynamo and the cars, to the energy which is usefully expended in the operation of motors and lamps, and thus bring them under the same rules of economy which have long been recognized as vital in the operation of incandescent light systems. Experience is bringing all engineers to realize more and more clearly that pressure is all they generate, and all they have to sell; and that it is so expensive as to make it vital that only a proper proportion be lost in transmission, with reference to the cost of the conductors in traversing which it disappears.

(c) Normally Innocuous Wires. Of course the safety or danger of any system of wiring, from the insurance standpoint, depends upon the restriction of the electrical pressure applied to it, or the difference of potential which may at any time exist between any of its conductors and the ground, and this is of as much importance as that of the current which traverses the wires shall be kept below a certain maximum. The safety-fuses are posted as sentinels to guard the current flow, and they are able to do it, if properly made and selected, quite irrespective of whether the current comes from a normal or an accidental source. We rely for the limitation of the total pressure generated entirely upon the regulation of the dynamos or other sources of electricity which are normally attached to the circuit, and if by any accident a contact is made with an outside circuit of higher pressure, for which the insulation inside is not adapted and which is beyond its strength to restrain, something is likely to happen, not necessarily at once but at any moment. The high pressure is there even if it does not immediately jump to ground or to an opposite wire, and waits its opportunity. Whether this opportunity affords itself within a few minutes or not depends absolutely upon the ability of the insulation to resist the particular degree of pressure to which it is subjected, for the difference between the pressure generated by a single cell of ordinary chemical battery and that expended in a lightning flash is only in degree, not in kind. A very ludicrous performance was formerly enacted at frequent intervals by makers of various insulating coverings for electric conductors. They were accustomed to soak a sample of wire in a bucket of water for so many hours and then measure its insulation resistance by one cell of battery and triumphantly announce that it showed 4,000,000 ohms per mile, consequently it was just what the electrical world had sighed for to restrain any pressure which might be transmitted by the wire. With more experience such tests are made by applying to the immersed conductor the pressure which it is expected to endure in practice, and in this way we have a variety of insulating wrappings which are actually as well as theoretically valuable, as long as they retain their prime essentials of continuity and refractory resistance to the ever-crowding tension within. The difficulty is, they are acted upon by heat and cold, by moisture, by insects, by rats and mice, and by their own chemical constituents. So while a telephone wire may to-day be able to stand the pressure of an arc light circuit, we have no guaranty that it will retain that ability until tomorrow, and therefore a very sensible rule has been made and widely adopted that every telephone, district messenger,

DIAGRAM II.

TELEPHONE CIRCUIT CROSSED WITH STREET RAILWAY LINE.



burglar alarm, watch clock electric time and other normally harmless circuit, must, if in any portion of its length it is liable to become crossed with another circuit carrying currents for light or power, be provided near the point of entrance to the building, with some protective device which will operate to shunt the instruments in case of a dangerous rise of potential, and will open the circuit and arrest an abnormal current flow. Much has been said about the alleged setting of a serious fire in Boston by a time wire which was stated to have become crossed with a high pressure circuit. Nothing was proven in this case, but the discussion has been fruitful of good in the recognition of the liability of such an occurrence, and in the making of a law in Massachusetts which compels all the telephone companies and constructors of similar circuits in that state to use such a device as will operate on a rise of pressure alone, and in combination with this, a means of cutting the circuit if this rise of pressure results in a dangerous current. It is of great importance to remember that presence of the dangerous pressure alone will not necessarily operate any ordinary form of cut-out, because most of these forms depend for their action upon actual flow or expenditure of the pressure. In the case of the telephone line assumed in connection with the railway circuit of Diagram 10, such a potential device is shown in a very simple form, an air-space cut-out which may be set to operate with 50 or 75 volts, and short-circuit the instruments at each end, after which the rush of current due to the 100 volts, between the two ground plates, along the line, and with no resistance excepting that of the wire, will quickly melt the fuses. Such a device would be equally useful whether the contact between the telephone and the railway circuit were through the earth alone or between the over-head portions of the respective circuits, whenever a dangerous pressure was attracted to any portion of the telephone line. No device relying wholly for its operation upon a flow of current can ever be effectual in guarding against this class of dangers, and no further illustration of this is necessary than that afforded by "Diagram 11—Telephone Circuit Crossed with Street Railway Line," which roughly illustrates a metallic telephone line, that is one which is completed by wire outgoing and return without connection with the earth, assumed to have accidentally come in contact with an electric railway circuit. If at each end of such a metallic circuit a device be provided which will operate upon a rise of potential between its terminal above a predetermined standard or limit, and one side of this device be connected to earth, the course of the small arrows in the diagram will show that the potential at each telephone will instantly become as high as the potential of the railway circuit at the point of accidental contact. Of course this potential is practically a measure of the difference between the trolley wire and point in the earth to which the ground wires of the potential protectors may be led. Hence if the protector be set to operate when the difference of potential between its plates reaches 100 volts, for example, then such a contact as is here illustrated would instantly result in the passage of two sparks across the air spaces in the two protectors at opposite ends of the line, and a flow of current from the cross on the trolley wire to both protectors which would melt the two fuses between the line wire and the ground connections and thus instantly detach from the complete telephone circuit that section on which the cross has

occurred. In such a case it would be unwise to even attempt any construction which would automatically re-establish the circuit. The skill and judgment of the inspector should be an essential condition of bringing the line back to normal operation and the use of proper precautions against a recurrence of the difficulty.

In order to make a device of this kind reliable, the surfaces between which the spark must pass as the result of a rise of potential must be brought very close together, say from 1-1000 to 3-1000 of an inch separation. No means of retaining two surfaces permanently and reliably so close together as this without the danger of their coming into actual contact, have as yet been devised with the exception of some form of distance piece upon opposite sides of which the surfaces may bear. One very good construction is to turn into opposite ends of a threaded non-conducting and non-combustible cylinder or tube, such for example as lava, two metal or carbon screws bearing upon a washer of mica, through the aperture in which the spark will pass. Such a form appears as Fig. 2 of Diagram 11. Thus if the resulting current should be sufficient to fuse the two surfaces together or to create an arc between them, such fusion or arc would occur within non-combustible walls, and would simply result in making the circuit of greater carrying capacity at that point than anywhere else, and insure the melting of the safety fuses. Such a potential cut-out can also be relied on to protect delicate instruments from lightning discharges or the induced currents which often traverse telephone and other circuits at the moment of such discharges. If the discharging surfaces are of carbon, the spark will not be apt to leave them connected, so that such cut-outs may be expected to act repeatedly without renewal.

Protectors substantially of this construction have within a few years been widely used in the large telephone offices of this country, particularly on long distance metallic circuits.

Commenting upon the liability of the setting of fires from wires which while doing their own proper work never carry currents of sufficient pressure or quantity to be dangerous to surrounding materials, Captain Brophy, in the paper before the Society of Arts to which I have elsewhere referred, well says:

"Next we come to the greatest fire hazard from the over-head wires—the danger of electrical contact between the harmless low tension and the dangerous electric light and power wires. The arc, incandescent, power, railway and alternating wires are capable of doing great damage in this way by sending currents greatly in excess of the safe carrying capacity of the smaller wires, and heating them sufficiently to cause the ignition of any inflammable substance in the immediate vicinity."

This statement does not, however, include the other and co-operative important necessity arising from the fact that contact between a high pressure line and a conductor normally innocuous, may sometimes raise the latter to a high standard of potential as compared with the earth or with other conductors near which it may pass in its course through a building, but may not actually send a current through it at once. Evidently it is practically as dangerous to have a telephone, district messenger, telegraph or other circuit which is always treated as if it were harmless, charged to so

high a pressure as to finally establish a leakage to adjacent wires or pipes, because such leakage may at any moment result in a flow of current so small as not to heat the telephone wire but capable of carbonizing its insulating covering and wood work or other combustible material which lies in the path of the leaking. Such a wire thus charged may be also a menace to human life, as for example when a telephone is taken off its hook by an unsuspecting customer of an exchange. I think Professor Elihu Thomson had all of these difficulties in mind when at the close of a most interesting and practical address before the National Electric Light Association, February 13, 1890, on the subject of "Safety and Safety Devices in Electric Installations," he is reported as using the following language:

"A discussion of this general subject, however brief and necessarily restricted in scope, would be very incomplete without allusion to the subject of contact with telephone or telegraph wires of electric light conductors. Underground and in conduits such contacts could not easily occur, though leaks might readily take place between lighting conductors and other wires. In any case there is a risk of such wires carrying current into buildings or to positions bringing about shocks to persons, thus involving risk of fire or danger to life, or both. As a consequence a set of safety devices have been brought out under various names whose purpose is to cut off dangerous currents when they reach or traverse lines, such as those of the telephone or the telegraph. It is my opinion that in cities the provision of approved devices of this kind should be compulsory. Most of those which I have seen are not well enough designed or made to be perfectly relied upon, but are much better than nothing and may possibly suffice. Such apparatus, however, should be made so as to be perfectly reliable and undergo a regular inspection. Mere fuses, even if made long, are not enough. There should be placed in every circuit liable to contact with lighting or such like conductors and at a place in the circuit where it enters a building, a protective device which, to be complete, should shunt or absolutely cut off the section of wire in doors, or ground the same in case of abnormal current on the wire or abnormal potential."

The devices alluded to by Professor Thomson as being on the market are for the most part dependent for their action upon the heating effect of a current flow, as in a safety fuse or a thermostat, or on the vitalizing of a magnet by the current which may in case of accident flow along a protected circuit, the movement of an armature in case of such abnormal flow operating in various ways to open the circuit entirely or to shunt a portion of it, usually the instruments placed upon it. Efforts have been made to construct such safety devices so that they will be automatic in reestablishing the circuit, and thus to avoid the necessity of that inspection which Professor Thomson considers so essential.

The National Code has the following compulsory rule regarding the use of protecting devices of this sort:

"All conductors connecting with telephone, district messenger, burglar alarm, watch clock, electric time and other similar instruments, must, if in any portion of their length they are liable to become crossed with circuits carrying currents for light or power, be provided near the point of entrance

to the building with some protective device which will operate to shunt the instrument in case of a dangerous rise of potential and will open the circuit and arrest an abnormal current flow. Any conductor normally forming an innocuous circuit may become a source of fire hazard if crossed with another conductor through which it may become charged with a relatively high pressure."

The Central Station Hazard. This is a department of fire insurance underwriting which should be considered by itself, so important has it become in recent years and so much have losses of this character alarmed the insurance fraternity. It is so important that the intelligent underwriter makes a study of the special conditions of such stations and it is so evident that they are by no means confined to their electrical features that one or two quotations will serve to point the way.

In a most interesting paper read before the 17th annual meeting of the Fire Underwriters' Association of the Pacific at San Francisco, Feb. 21, 1893, Mr. George P. Low graphically portrayed the causes of fire in some of the earliest electric stations in this country. Mr. Low's papers are well known for their terse instructive style and I commend this particular one as disclosing much that the insurance student of electricity wants to consider, but in many cases don't know where to find. He said, as reported in the Western Electrician of March 18, 1893, page 146:

"We are all too familiar with the makeshift construction of the buildings that contained these original stations. In many cases the buildings were put up with absolutely no regard for fire risks. In them were placed valuable plants consisting of steam and electric machinery. Boilers and engines, with their fire boxes, flues, piles of fuel, steam pipes, oil and greasy waste, constitute a fire hazard necessitating on one hand the exercising of no little skill in its operation; dynamos, with their accessory appliances and wiring, all laden with a new and most potent form of energy, the hazards of which were unheard of and unknown. Then again, as defined in our typical station, the projectors of these early stations were all venturing in an untrodden territory. They did not know the fate their enterprise would meet; they simply advanced upon belief, and under such a condition it is but natural that every unneccessary expenditure should have been avoided. Everything was temporary and as cheap as possible; apparently no one knew how to erect a station on any other plan, or at least no one had done so.

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"As it is, probably one-half of the companies refuse to write on electric stations, no matter what the merits may be. The wisdom of making the prohibition absolute may I think well be questioned, for certainly few manufacturing plants contain less material of a combustible nature than the modern fire-proof central station. The textile mills have their cotton, woolen lint and goods, grist mills have their feed, grain and explosive dusts, wood working industries their piles of sawdust and shavings, but the modern electricity factory, with its thoroughly fire-proof construction, its steam plant, its dynamos, its switchboards and accessory instruments, is absolutely incapable of supporting combustion, for the iron and steel of the steam plant, the iron and copper of the electric machinery, the marble and slate of

the switchboard, which within brick or stone walls, with iron roof and with concrete floors, constitute a modern electric station; these will not burn. The product of its whirring armatures, unlike the products of clashing looms, or grinding rollers or roaring planers, does not remain a constant menace to the premises. Instead, its product in the form of hundreds or thousands of horse power of marketable electric energy is unseen and unheard. The laws for controlling it, being now fully understood, are fully carried out and in the modern station the occurrence of fire is impossible. Indicate if you will a more desirable risk."

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"In alternating transmission is found therefore a new class of risk with which underwriters will have to deal, and it is well to enumerate the additional safety features which the use of this method of electrical distribution entails. First, the generating station is almost invariably located at sources of natural or cheap power. Real estate is not so valuable there as in cities, and it is reasonable to presume that the station will not have any great exposure, or indeed, it may be absolutely isolated. Second, the dynamos will in all probability generate only low potentials, which offer less hazard than the high ones commonly used. Third, the use of high potentials is restricted entirely to the sub-station vaults referred to and to the outside pole lines. Finally, the switchboard and the valuable instruments thereon for controlling municipal and commercial circuits are located in the sub-station, where, as stated, they are subjected to a minimum exposure. The switchboards will moreover handle only comparatively low potentials."

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"It must be evident then that, as stated, the electric station is in a state of transition. It is also evident that electric stations as we find them to-day naturally resolve themselves, according to their construction and equipment, into the original type and the modern type. With the former, we are all too familiar, and underwriters will not soon forget the experience they have bought concerning it."

"Of the modern station as a whole we have no experience, nor does it appear possible that we are likely to learn any disastrous lessons from it. It is almost too recent a creation to be able to guage its worthiness as a fire risk by statistics, but there is not an element in its construction with which we are not perfectly familiar in one way or another. We know that a building constructed entirely of brick, iron, stone and cement will not burn; we know that a steam plant may be placed with perfect safety in such a building. We know, too that the placing of the pile of iron and copper called a dynamo in that building will not render either it or the steam plant more combustible, neither should we believe that the addition of a frame work of iron piping and the securing thereon even of mysterious instruments of brass, copper and slate will add to the inflammability of the rest of the premises, and even though this combination of iron piping and intricate instruments be known as an electric light switchboard."

"Here permit me to reiterate one fact, and let it be recorded, even though every other be forgotten: There are two classes of electric risks—

the original electric light plant and the modern electric station, and to guage the hazard of one by that of the other is impossible."

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"It is not to be questioned but that the old form of electric station is deserving of high rates. The underwriter's position in this regard is impregnable, but where he has committed his error is in failing to recognize by reduced rates new departures in station construction which have unquestionably increased the safety of the plant. The underwriter is slow to forget his losses on electric light plants, and these were so severe that he fails to realize that there are electric stations and electric stations. This has led electric interests to erect their stations so as to be as near fire-proof as possible, with the idea of carrying their own insurance."

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"The existing situation between insurance and electric interests may be summed up as follows: The electrical fraternity, forgetful of the injury it has inflicted upon underwriters, is thoroughly dissatisfied with the present rates and methods of insurance procedure and is devoting every energy to eliminate the hazards of the business with the idea of carrying its own insurance. On the other hand the underwriters, smarting under the losses they have borne, fail to recognize the improvements that have been made in electrical construction. This you must do or some day it will transpire that electric stations have placed themselves generally beyond the necessity of insurance. Whether the idea is tenable or not, it is the one now held by electrical people the country over, and as such it demands your consideration."

Commenting upon this, the London Electrical Review of April 21, gives some facts as to the small difficulty which is met when English methods of inspection are practiced, and draws a conclusion that ought to convince every insurance reader in America that his own education may assist in hastening the good time coming, because all that is needed is a faithful application of well-recognized rules of safety. The following is from the editorial found on page 450 of the issue referred to:

"The fire hazard of electric lighting, though a well-worn subject, succeeds in cropping up from time to time, and is the theme of many a paper, and the fruit of many a discussion. In this country, however, matters have so far settled down that we now rarely hear of those mishaps formerly attending electric lighting, and the fire offices have little to complain of in the way of, so-called, electrical fires. In America, however, the case is somewhat different. Complaints still reach us of the unsatisfactory—not to say slipshod—manner in which many of the installations are carried out, and we believe the fire offices have good cause to regard the 'light of the future' as anything but an unmixed boon in that country. It would appear, also that the same experience applies to the generating stations, which have proved during the past few years to be very unremunerative risks; so much so, indeed, that some insurance companies decline to entertain them on any terms, while others charge practically prohibitive rates, or impose conditions unacceptable to the lighting interests. Why the grinding out of electricity should be so hazardous an operation in the states is more or less a mystery,

and we have for a long time looked in vain for some statistics dealing with the question."

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"It is now pretty evident that the high loss ratio is due not to this or that particular system of distribution, nor to any particular device or apparatus employed—in fact, to nothing that may be said to be specially inherent in electricity itself—but to causes appertaining to any factory or works where power is employed, and where the arrangements for such are faulty. During the rush in the early days of electric lighting, any shanty was considered good enough for a generating station, the main thing being to get the current along and the money coming in. Hence it is not surprising to find that of the 87 stations referred to, nearly 50 per cent. are timber buildings, and several are joint occupancies with other risks, such as planing mills, saw-mills, and flour mills."

Bearing upon this question of the insurance of central station risks, some excellent remarks were made not long ago by C. C. Haskins, electric light inspector of the City of Chicago, in an address before the Fire Underwriters Association of the Northwest (at the meeting of September, 1892). Mr. Haskins has a way of putting an idea so plainly and forcibly that the most obtuse hearer cannot fail to appreciate his argument. He said:

"There was a time within the memory of man when any old barn, wood-shed or cow-house was plenty good enough for an electric light plant. A wheezy, rickety engine was hunted up somewhere, patched up and put in service. Two, possibly three boys were set to run the machine, and ten chances to one the whole outfit soon went up in smoke, or down through the sheriff's hands to the unhappy creditors. Is it any wonder that underwriters were afraid of electric light plants, and property through which wires were run helter skelter by men who knew little of electrical laws, to be inspected by those who knew less? No wonder that the smoke from electric fires blackened the eyes of electrical enterprise, and made the underwriter wince with dread. The novices, the schemers, the speculators who crowded the ranks, the half-baked electrician who talked of 'computators' and presented you his business card with 'electrical engineer' engraved upon it; these are nearly all gone, and the business has fallen into legitimate competent hands."

"Station houses are better built, wires are more carefully selected, greater pains are taken in construction, the entire enterprise is settling down to business and a scientific basis, and in all the larger cities careful supervision of plants has been inaugurated by the underwriters or by municipal authorities, or both."

The statements above and those quoted elsewhere in this paper from well-known authorities as to the causes of electrical fires are somewhat in contrast with the vague terror which is expressed in the report of the Committee on Lighting, Heating and Patents of the National Board of Fire Underwriters, dated New York, May 12, 1892, and signed by John H. Washburn, chairman, and others. This report is well calculated to carry distrust to the minds of those who have not investigated the subject, as in the following quotations:

" But when we come to talk about electricity, its uses and beauties, its properties and its dangers, your committee could fill volumes in telling you what they do not know. And herein lies our present trouble. There is so little that we do understand about electricity, and our ignorance is so dense that we may well stand appalled in the presence of dangers which we know are great but the magnitude of which we are too ignorant to appreciate."

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" In accounting for these mysterious fires we are almost forced to conclude that there is at present an unusual moral hazard, that merchants of the highest standing have become incendiaries, and too without any apparent reason, or that the electric current introduced for lighting is chargeable with the loss. We are not prepared to attribute these losses to criminal design, and can only believe that this new mysterious agent is the cause."

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" It is hardly practicable to secure all over the country a system of inspection which shall insure the introduction of the safest and best appliances, and harder still to watch the changes which from time to time are liable to detract from the safety of plants originally approved, and yet such rigid inspection would seem to be necessary if the condition is to be improved."

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" Your committee would also call attention to the hazard of electric plants, especially those on a large scale, arising from the peculiar condition of the atmosphere caused by the generation of electricity in considerable quantities. Your committee have not sufficient scientific knowledge to explain this condition, and this idea has been ridiculed by so-called experts, but there is no way of accounting for the sudden and rapid spread of fires in such plants except on the theory that electrical action has so affected the atmosphere as to make it a ready and active supporter of combustion."

The insurance inquirer on the subject of electrical risks may turn with some relief from such "editorial" utterances, and read the closing paragraphs of Capt. Brophy's Society of Arts paper:

"I will now close by saying that the man or firm who will take advantage of the limited knowledge of electricity possessed by the average citizen, and install electric wires in such a way as to increase the fire hazard, should be deemed guilty of a misdemeanor and should fire result should be deemed guilty of arson. The electric lighting company who would connect its service wires and furnish current to a building unsafely wired should be deemed an accessory before the fact and punished accordingly."

" It is within the power of those engaged in installing electric lights and wires and furnishing electricity for light and power to greatly reduce the fire hazard, and stop the complaints of underwriters of the increased number of fires due to electricity."

The captain was present at the National Electric Light Association Convention at St. Louis, Feb. 28, 1893. He also had his gun with him and used it, as the following extracts from his paper read at that time testify. (Electric Power, March, 1893, Page 28):

"In this way the inspector, instead of assuming a knowledge which he did not possess for the sake of increasing his own importance in the eyes of those who employed him, kept in touch with those whose daily experience enabled them to detect any inherent weakness in the devices and systems of transmission, and enable him to assist in perfecting the same by advocating all improvements that increased the safety and did not impair the efficiency of the system. In this way the standard of safety has been raised to a degree that approaches perfection."

"In this way fire losses caused by electric current decreased, notwithstanding the enormous increase of electric light, power and railway business, and the fears of the insurance companies were in a great measure allayed. In marked contrast with this mode of procedure is that of certain insurance inspectors and others who are now engaged in an attempt to undo all that has been done to bring about an era of good feeling between these two great interests and enable them to work together harmoniously."

"To those inspectors who are engaged in an attempt to throw discredit on those in the electric business by practically saying, 'You are not to be trusted,' I will say, 'Beware! the electric industry is not the puny infant it was some ten years ago. Millions are now investing in it, while the phenomenal growth of the electric railway challenges the admiration of all and it is fast attaining the vast proportions of the electric lighting industry. These joint industries will submit good naturedly to all reasonable requirements exacted by your employers, but they cannot be expected to submit to continual annoyance or admit that they are unable to conduct their own business, or allow it to be done by those who seek to do so by might and without a shadow of right. The electric light business can exist without the fostering care of these self-appointed guardians. Because they are tolerated they must not seek to dictate, as there is a point beyond which forbearance ceases to be a virtue with all classes, and electric lighting companies do not differ materially from the rest of the human family in this respect.'"

"I will try to point out the best methods to pursue to stop the silly twaddle about the danger of electric lighting by professional agitators, sensational newspapers and timid old ladies of the male persuasion, and deprive the smart insurance man, who insists that there are hidden dangers contained in every portion of the plant, that compel him to charge an increased rate of premium for its production and the use of his stock in trade."

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"The real fact of the case is that (in Boston) millions of insurance has been placed by the agents and brokers on property that is far more hazardous than the very poorest electric light plant in the business portion of the city; ordinary prudence having been thrown to the winds, in writing such insurance, the inevitable consequences of such folly ensue, viz: disastrous fires. The agent who sees a possible loss of commissions hastens to give a plausible excuse to his companies, by charging the origin of the fires to electricity, and demands an investigation of the fire department for not extinguishing them before they were kindled, concealing the fact that his

own methods of placing insurance encourage incendiarism and promote carelessness."

Alternating Systems. This suggests the only features of the Alternating System of Diagram 12, to which I need especially refer. The rules for interior wiring of all multiple arc circuits are framed upon the theory of restricting the pressure applied to them to a maximum of 300 volts. To allow an indefinitely greater pressure would be as hazardous as introducing a speed of 50 miles an hour on the New York elevated railways or on the cable car lines of Chicago. It would be like letting into the distributing pipes of a city domestic water system the pressure of 1,000 pounds with which the hydraulic mining engineer tears down the side of a mountain. Before the 1,000 volt current (which because of its high pressure allows of great economy in the long transmitting conductors) can be safely admitted to your residence, it must pass through a reducing valve, as it were, and such a device is the converter. The watchful and intelligent inspector of the underwriters has decided that this converter is safer outside of the house than in it, and so only the reduced standard of 50 or 100 volts is admitted. But suppose the mechanism of the converter gives way, and the 1,000 volts enters, then a sentinel should stand at the door to cut the circuit and stop all action. Such a sentinel is the same sort of a potential device which is applied to the telephone circuit to protect its instruments and the surrounding material which might be ignited, and it can be made as effective in the one case as in the other. On this point C. J. H. Woodbury, in the Cornell University lecture elsewhere referred to, said:

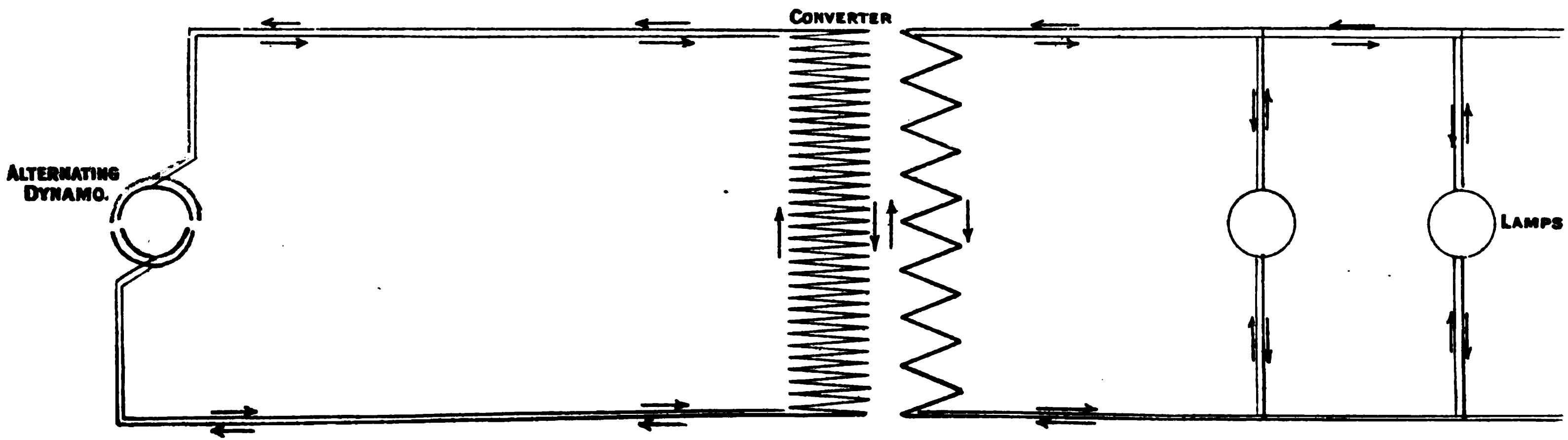
"Converters should be equipped with safety fuses at the junctions of all feeders and mains, and furthermore, the wires of the secondary circuit should be protected against the current of the primary circuit from reaching the interior of the building by the use of air or film cut-outs connected with both poles of the wires of the secondary circuit near to the converters, in order that if there should be any direct electrical conductivity from the primary to the secondary circuit, the primary circuit would be grounded at once. These cut-outs are generally adjusted to operate whenever the current reaches a potential of 350 volts. It is not desirable to ground permanently one of the wires of the secondary circuit, because in such case the wires have the same fire hazard as if the circuit was furnished with electricity from a dynamo, which would be diverted from the system whenever a second ground occurred; and it should also be borne in mind that the alternating currents tax an insulation more severely than a continuous or even pulsating current, and that as a practical matter the primary circuits of an alternating system conveying currents of high potential are almost always grounded."

In the recent address from which I have elsewhere quoted Mr. George P. Low expresses a different view regarding the influence of the alternating current upon the insulation of conductors referred to in the last sentence of the above quotation from Mr. Woodbury. Mr. Low says:

"Regardless of earlier apprehensions the fire underwriters should rejoice at every advance made by the alternating system. To illustrate: A large, thoroughly modern fire-proof building which I have in mind was lighted by incandescent lamps operated on the alternating system. The plant was

DIAGRAM 12.

ALTERNATING SYSTEM OF INCANDESCENT LAMPS OR MOTORS.



operated to entire satisfaction for nearly a year, when a direct current was substituted for the alternating source previously used, and in a remarkably short time trouble after trouble was developed, circuit after circuit was burned out, and eventually it became necessary to re-wire the entire building. The insidious electrolytic action, which sooner or later disrupts continuous current circuits, is nearly though not quite inappreciable in alternating systems."

A comparison of these two statements suggest the great importance of gathering and preserving information as to the difficulties which are found to exist in the insulation of the direct current and alternating current interior wiring, and thus determining whether any advantage which may be discovered in practice is due to the difference in the character of the current or in the standard of pressure.

The Inspection Problem. We have thus considered several of the possible hazards presented by systems of electrical distribution. In spite of their somewhat formidable appearance when recited seriatim, they are rapidly being reduced in practice until it has come to be true that none of them is serious if the well-known rules which have been formulated in "The National Code" are actually and faithfully enforced.

It is true that various modifications should yet be made in the detail of apparatus specially applied to the securing of safety in cases of accident. For instance, it is true that if safety fuses should be more carefully made and standardized as to their melting when enclosed beneath a cover of standard size and standard material and traversed by standard current in standard time, we might feel more sure of their quick response in time of need; that they should be, as applied to the small conductors, larger than they are usually placed, in other words selected of a size to protect the wire between them and the lamps, rather than for any given number of lamps or amperes, so that their melting with little variations of current would be less frequent and their replacement with copper wires by careless workmen would be an annual instead of an hourly occurrence; still such practices are now restricted to fuses of small size. It is true that they should have hard metal ends instead of enlarged ends, thus insuring continued good contact when once carefully placed; that they should be non-interchangeable, that is, a fuse block should accommodate one and only one size or capacity of fuse; that they should always be shut in by a non-combustible cover, so that in case of a violent short-circuit the explosive action of the fuse may not ignite anything which the vapor may reach; still the bases have been vastly improved within five years. It is true that series arc light wiring for interiors has been a source of great anxiety to the conscientious inspector on account of the high pressure used, but the series arc lamp is being rapidly displaced in such locations by the constant potential arc lamp, which operates steadily and satisfactorily with the same low pressure conductors from which incandescent lamps are supplied, and it is also a fact that by the aerial suspension of conductors in interiors, the series method has been made satisfactory to the underwriters.

Since these and other details of the systems of lighting and power have become more fully understood, the question of how best to enforce the rules against those who violate them has justly taken a place of great

importance. The most vital aspects of the case are three in number, and all deserve the most careful consideration by the underwriters. They are the disregard of the rules which is shown by certain classes of constructors; the disregard on the part of certain classes of inspectors; and the necessity of inspection of central station consumer's interior wiring by the illuminating companies.

These should be treated more in detail.

(a) Disregard of the rules by constructors: Those who are guilty of this disregard belong to three classes, Electrical Tinkers, Electrical "Experts," certain Illuminating Companies.

(1) Electrical Tinkers. This first class is made up of men who have dealt in harmless forms of electrical apparatus, call-bells, gas lighters, burglar alarms and the like. Their stock in trade usually consists of a long quarter inch bit, a pair of five inch pliers, a reel of parafine covered wire, a screw driver, and complete ignorance of the power that is represented by electric light and motor circuits. The loftiness of their assurance equals the density of their ignorance. They have been a menace to the business since its earliest days, and so important a matter is this to the underwriters to-day that it is profitable to recall a few of the many warnings given to the public within the last dozen years by those insurance men who have lived closest to the vital issues of the electrical business.

Many old timers in the electric light field will recall that with the first proposition to install electric lights in a town or city, persons who had been engaged in the business of placing electric bells and gas-lighting devices at once advertised their ability to wire buildings for incandescent electric lamps, and in many cases actually placed such wiring without any knowledge whatever of the new conditions which had been disclosed and in accordance with which wiring must be done to adapt it to the carrying of currents generated by dynamos actuated by powerful sources of mechanical energy. These incompetent persons began their work very early in New York City, Boston and other places, and even as early as the date of the reading of the paper of Mr. Anderson to which allusion has been made.

The fire insurance people had even in 1881 been so much impressed with the dangers which threatened their business from this source that Mr. Anderson felt called upon to warn his associates of the United Fire Underwriters by the following paragraph, which occurs on page 11 of his paper, as printed in pamphlet form:

"Underwriters should see that false economy is not practiced at their expense, and bear in mind that it is much easier to guard against dangers at the outset, than the contingencies which will naturally follow the evils referred to, and the placing of the management of the electric machines and attachments in the hands of incompetent persons."

Two months later, in issuing the first report on electric lighting, from which a quotation has been made, Mr. Edward Atkinson said:

"We add also one word of caution. Our members should be careful with whom they deal, and be perfectly sure not only of good and safe work, but also of the responsibility of the contracting parties, both with respect to the character of the work and of immunity from loss, in view of the fact that the whole subject may be said to be shingled over with patents."

Mr. Atkinson again called attention to what he appears to have considered a matter of great consequence, in his second electric lighting report, dated February 7th, 1882, as follows:

"The especial danger of contact of wires would, of course, come from the use of naked or uninsulated electric light wires put up by irresponsible companies or agents, but accidents have occurred from the wearing away of the insulating covering by abrasion. Members cannot be too careful with whom they deal, and may be assured that responsible electric light companies are using their utmost efforts to maintain all the conditions of safety, both in respect to public and private wires and are heartily co-operating with us in providing for every possible contingency."

For the third time, in the subsequent report dated March 6th, 1882, Mr. Atkinson warned his associates of the Boston Manufacturers Mutual Fire Insurance Company:

"Between the two systems called arc and incandescent, the underwriters must give preference to the latter, which system may, we believe, be brought as near to absolute safety as any method of lighting can be; while the former, we believe, may be made as safe as gas or oil, probably safer, when carefully put up by responsible companies and kept under proper supervision or inspection; we may not at present venture beyond this judgment."

On February 3d, 1885, a paper was read before the Society of Arts at the Institute of Technology in Boston, on the "Edison Three-Wire Central Station System," and occasion was taken in the course of that paper to call attention to the dangers which, at that time, existed from the improper work which had already been placed by incompetent concerns, principally by electric gas lighting concerns having no experience in the handling of powerful currents. In the course of the discussion which followed this paper, Captain William Brophy, who was then acting as inspector of electric lighting risks for the New England Insurance Exchange, said, as he was reported:

"It will not do for people well versed in telephone and other wiring for light currents to assume that they are competent to wire for electric lights; if they do, the public and the underwriters will have to pay dearly for it."

In the issue of the "American Architect" of February 7, 1885, Mr. F. Elliot Cabot, then and now acting as chief inspector of the Boston Board of Fire Underwriters, said, in the course of an article on "Electric Lighting:"

"When the current is furnished by a local company, it is usual to have them do all work of putting in wires and fixtures, and I would advise all persons intending to have wires put into any building to employ the services of an electric company for this work, and not to entrust it to men who are only accustomed to wiring for electric call-bells, gas lights, and the like. The work of putting in wires for electric lights is a very different matter from any other kind of wiring and requires a knowledge of electrical resistance and of the heating power of lighting currents which most of the bell hangers by no means possess. In one house which I was asked to inspect quite recently, part of the work was done by men quite competent to do the wiring for electric bells and gas lights, but in wiring for incandescent lights, they had used nearly twice as large a wire in some places as was necessary, and in others had gone to the other extreme and used wire much

too small. They had also placed the wire in such a way that a fire would have been almost inevitable had the wires ever been used for electric lighting."

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"I cannot express too strongly the feeling I have against concealed wires for electric lighting, in connection with the risk of fire. When wires are in plain sight, any trouble on them will probably be noticed before it causes fire, particularly if inside buildings, but with concealed wires it is very difficult to discover any disarrangement before the wire gets to a dangerous state. All wire for electric lighting should be protected by a covering not easily removed and not inflammable. Paraffine should be particularly avoided in the insulating covering, as rats are very fond of this substance, and are likely to knaw the covering off the wire to obtain paraffine."

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"All circuits, whether for arc or incandescent lighting, should be kept carefully away from water pipes, gas pipes and other metallic bodies likely to make a connection across the wires, or from one of them to the earth, and should be so placed that there shall be no danger to the insulating covering from tables, chairs or other movable objects. If the precautions noted here are observed, and the wires and dynamos installed by persons familiar with this kind of work, and the whole handled in accordance with directions obtained from them, I believe electricity to be the safest method of illumination yet discovered."

These cautions contained in the article of Mr. Cabot are particularly significant to one who recalls the state of the art up to a period one or two years later than the date of Mr. Cabot's utterance, because of the large use by the electric bell hanger and gas lighter of paraffine covered wire, and his facility in concealing this wire from view by an operation known as "fishing," this method being one of feeling out by a steel wire a course from one opening in a floor or wall to a similar opening at a distance, and by this wire pulling in the copper conducting wires from point to point throughout a building without seriously tearing up the floors or cutting into the walls. Even where this method of placing improperly insulated conductors was not practiced, and the danger of dragging such conductors and leaving them in contact with the surfaces of water, gas or other pipes, was avoided, the electric bell hanger ordinarily ran his wires from some point where they were bunched together, without the least regard for the proper fusible cut-outs or other measures of safety, in the straightest line possible, to the different outlets at which electric lamps were to be connected.

There was no class of contractors by whom the safety and real progress of the electric lighting business has been for years so gravely menaced as these "electricians" who had made it the business of their lives to wire buildings for electric bells, burglar alarms and gas lighting devices, and had obtained no actual personal experience as to the new features and the elements of danger that were brought into the art by the advent of electric lighting. The more absolute their ignorance of the peculiar problems with which they would be obliged to deal in this new field of work, the greater

the apparent complacency of their assertions that they were fully equipped to wire buildings for any purpose of this kind. It may safely be said that, even up to the year 1886 and perhaps later, they were by the insurance companies more dreaded as mischief makers than the great number of men who, of necessity, came into the business without any electrical experience whatever. An entirely ignorant contractor would hesitate at that stage of the business about undertaking electric light or power wiring. The assurance of the bell-hanger showed conclusively the truth of the old proverb that "A little knowledge is a dangerous thing."

It may be permissible even to dwell still farther on this point because within six months a prominent representative of the electric gas lighting industry has made under oath statements which lead to the conclusion that if wires placed for the purposes of electric gas lighting will serve to conduct current to spark devices requiring a pressure of more than twice that needed for ordinary incandescent electric lamps, and if platinum spiral gas lighting devices sometimes require more current in amperes than a single incandescent electric lamp, then a system of wiring supported by gas fixtures which would answer the purposes of distributing current to electric gas lighting devices, will also answer the purpose of distribution for incandescent electric lamps. This is a most erroneous and misleading conclusion, first, because the sources of energy are in the two cases radically different in the power of the currents they are able to supply, and their ability to maintain such currents for a sufficient length of time to be dangerous; second, because an insulation which will stand a momentary electrical strain of a certain degree without breaking down, will often utterly fail where such strain is maintained, as in the case of the continued use of an incandescent electric lamp. A system of wiring that is good enough to answer the purposes of electric gas lighting, because it will do no damage if half the current or the whole current should leak through the insulation to the gas pipe on certain days in the year, or under certain atmospheric conditions, while at any other time it may be regarded as an operative system, would not only become speedily and permanently inoperative if connected to a source of energy supplying a lower pressure, but maintaining that pressure day after day (no matter how much flow of current might be occasioned by that pressure), but would as speedily become a source of danger which could not be for a moment tolerated. A gas lighting circuit may leak to-day at the moment of the temporary use to which it is adapted, and to-morrow it may have dried out, and be perfectly insulated for all practical purposes. Put the same system of wiring under the steady strain of one-half the number of volts supplied by a dynamo, and it might be expected to give out within a short time, and perhaps set a fire in doing so. The one feature of difference between gas lighting and incandescent lighting, of a dynamo representing a capacity for maintained expenditure of great energy, is of itself sufficient to make the problem of wiring for electric lights radically different from that of wiring for any other system of electrical translation whatever which had preceded it.

(2) Electrical "Experts:" The second class of constructors who disregard the rules is represented by the young fellow who works a month for J. J. Jones & Co., a good wiring firm, at 50 cents a day and is discharged for incapacity. By this time he has found out the names of the other people

in the business, and at once goes to S. S. Smith & Co., next door and gives the names of three concerns that will recommend him. Mr. Smith is too busy to look him up and hires him at $2.25 per day, but finding at the end of a week that he is worthless, sends him adrift. His fortune as an "expert" is now well started. He goes to Worcester or Boston or Detroit and advertises that he, having had large experience in the employ of the well-known engineering firms of Smith & Co. and Jones & Co., is prepared to contract to equip buildings of any kind with isolated electric light plants, comprehensive wiring and fixtures, or to construct a power station and an electric railway. He finds what reputable firms have bid, and offers to do the same work for three-quarters of the money. What wonder that it is fearfully and wonderfully vile, and that watchful manufacturers of good apparatus often refuse to supply it, to be connected with such construction work.

To such a pirate an incident related in a recent paper applies: (Western Electrician, May 13, p. 256):

"A curious proof of the thorough going nature of the inspections in St. Louis was furnished in connection with a job done by a Chicago contractor in one of our largest stores. The requirements were well understood, and the understanding was positive, that the concealed work was not to be covered until it was inspected. But the inspector found the concealed work boxed up, and the walls painted, and decorated in fine style before the work had been inspected. The certificate was refused. The opening was to take place in a day or two. No threats or objurgations of the Chicago man, who had never heard of such a high-handed proceeding in his life, nor even the entreaty of the merchant, the beauty of whose opening would be materially marred by tearing open the walls, could extort the certificate. We induced the merchant to stand firm and refuse payment till the certificate should be issued. The contractor was brought back from Chicago, the boxing was stripped off, and an incomplete, unsafe and skamped job stood revealed. It cost the fellow three days' work to make it right. When he got his certificate he swore he would not work in the town for $500 a month."

The mischief that these two varieties of the genus "lawless constructor" have done may be in some measure appreciated by recalling that it is only four or five years since a large proportion of the insurance men of the country first realized that they were confronted with a menace on the one hand in the shape of a force of which, as Edward Atkinson said, "they knew little, described in technical language of which they knew nothing," and a second menace on the other hand in the shape of a regiment of "experts" who chattered glibly long enough to show their idiocy and alarm their hearers. I have seen no better expression of the position from the Underwriters point of view than that contained in a paper read before the Electric Club of St. Louis, April 15, 1893, by Mr. James A. Waterworth, as reported by the Western Electrician of May 13, (p. 355):

"Electricity was the latest novelty that presented itself to the conservative eye of insurance. The new comer did not make a favorable impression. It was a new and ubiquitous force; it was reported by its best friends to be erratic, whimsical and even dangerous. It was known that it would burn; it was said that it would kill, and it was believed that nobody knew much

about it. It was popularly supposed that it took a conjunction of chemist and civil engineer to wire a building so that life and property would be safe. The coming king stepped on the stage with the reputation of an incendiary and anarchist. He claimed the right to enter every house and bring his incendiary habits with him. It was claimed that he could be permitted to enter and remain in a building with reasonable safety if — and here the electrical interests and the insurance interests met. Who was to decide under what conditions electricity could be introduced in our warehouses, factories and homes with reasonable security against setting the town on fire. Electricity brought with it a motley multitude of hangers-on and a foreign nomenclature. A new class of men, known as experts, seemed to spring like an exhalation out of all sorts of occupations—out of tinners' shops and plumbers' stores and out of boiler and engine rooms. These men knew nothing about electricity but they soon learned to prattle about volts and amperes and short circuits, and they paralyzed the boldest citizen with these and such like cabalistic expressions. They spoke with authority and claimed the right to decide what was safe and what was unsafe. In 1888 it took about three weeks to convert a mechanic into an electrical expert. The sudden growth of expert talent beat the record of Jonah's gourd. By a merciful dispensation the expert fungus perished as it had come — in a night. But while these men were contracting and doing work you may readily suppose they did not commend electricity to insurance companies as a harmless innovation. Some of the work done by them would make your hair stand on end. It is being condemned and taken out wherever found, often at great cost."

"The insurance agent is rarely more than ten years in advance of the community in scientific matters, and I confess that he didn't know a bit more about the electricity than the electrical expert. He wasn't so much scared by the electricity as he was by the expert talent. The insurance companies were scared, however. Whatever else they might or might not know about electricity, they knew they had to pay for it. They were right; they paid at once for the first central station in St. Louis — the Brush on Walnut street — and then they were sure that electricity was an incendiary of the first order. Do you blame them?"

(3) Illuminating Companies: The third class embraces some lighting companies that have considered themselves compelled to do free wiring of buildings for which they seek lighting contracts, and rely upon the cheapness of their work to save them from actual loss the first year. It has been a long jump from kerosene to electricity in many little towns which could not reasonably be expected to make one electric plant pay, to say nothing of two competing plants, but it is gratifying to be able to say that this cause of insurance anxiety is rapidly disappearing, because the ill-omened broods which the lighting companies thus hatch so soon come home to roost.

(b) Disregard of the Rules by Inspectors: There are two classes to whom this applies. In the first is the inspector who is hired by a board consisting of local insurance agents and paid from a fund exacted from the constructors or sellers of apparatus. Of course there are cities which are the homes of able executive officers of great insurance companies. There are also cities in which no such executives reside and where the local agent

finds that the study of electrical conditions might lead him to lose some commissions. The importance of the inspector is rarely appreciated under such circumstances, and his duties are perhaps made such that it is impossible for him to properly regard the rules and do justice to the subject.

It is always useful to see ourselves as others see us, and bearing this in mind, the executives of the Underwriters will perhaps not fail to get a profitable glance from the mirror which in a personal letter dated about two months ago, a bright observing writer holds up, respecting the method which a few cities have tried, namely calling in the fire department backed by the city ordinances, to do their inspecting of electric light risks:

"One great trouble with the insurance people is that they are always afraid of offending their customers and so losing business. If the municipal corporation orders something done for their benefit, then all is well, and 'we can't help it,' is the palliative salve they apply when a furious or injured customer presents his wound for sympathy or remedy, and the underwriter laughs in his sleeve to think how he has circumvented the property owner by means of the 'cat's paw cure.'"

Another well-known inspector says in a recent letter to me:

"I know a city in which the insurance people receive several thousand dollars per year from two electric light companies, and expend from 25 to 30 per cent. of it in inspections. The board consists of agents and brokers who put the balance in their treasury. They are to-day raising a howl of the loudest kind at the possibilities possessed by the electric current in setting fires, but they are too selfish to maintain the watchfulness over their territory for which the two prominent electric companies actually pay their money. Thus there is no really satisfactory check on the ignorant or irresponsible contractor. What sort of a farce must an inspection become which is required by a law which provides no penalty for violation?"

The inspectors of another class may be described as having charge of six states or territories each. They are forever needed somewhere else, and can never get there until the work is covered up. Then they give a certificate because the contractor says it is all right.

(c) The solution of one phase of the Inspection Problem will be found in the responsibility which attaches and must attach to the officer of the illuminating company (the local central station) who gives the order to connect a newly-wired building with the company's conductors. After current has been furnished, if trouble occurs, the customer doesn't look to the contractor nor to the maker of the fixtures; he calls for the manager of the central station which feeds his lamps and motors, and to him makes complaint. If it is suspected that the current has started a fire, it is the fault of the station; if the lights go out he sends for the station inspector; if he wants more light he calls at the station for larger lamps. Once attached, the manager cannot prevent his system from receiving a black eye if the service is unsatisfactory. Thus the necessity of inspection by an insurance man, of every move that is made will be avoided, and calls upon him will be gradually restricted to investigating the causes of fires where electricity is the most convenient scapegoat.

In his paper on "Relation of Insurance to Electric Lighting and

Power," before the National Electric Light Association last February, Captain Brophy said:

"Where a company does its own wiring for its customers, proceed with as much care as though the building in which you are installing wires and fixtures was your own, and you had no insurance on it. Where the work is done by others, inspect every foot of wire, every joint, cut-out, switch and insulator, and on no account turn on current until you are satisfied that it is as safe as it is possible to make it. Do not rely on the uncertain movements of the insurance inspector or any other system of inspection that too often fails to inspect. You are the one whose business will suffer from the bad effects of fires caused by defective wiring."

Pertinent in this connection, as pointing to the interest which must, at least for years to come, be taken by the underwriters, is the view of James A. Waterworth in the paper from which quotations have already been made:

"A prominent consideration determining the relations of the two interests is the authority, assumed or conceded, of making inspections. This may easily be made a ground of dissatisfaction and strained relations. But a little common sense will, I think, settle the matter. That inspection and control of electric installation is necessary and desirable, and beneficial to all, I think cannot be doubted. It is certainly necessary for the insurance interests, which have to pay for all the losses caused by its dangerous defects; it is necessary for the electrical interests, if the conscientious contractor is to have a show; and if the credit of the business and the public confidence in its safety are to be maintained, it is necessary for the light and power companies who need some test of the installations they supply, quite as much as the gas companies require a test of the gas pipes and fixtures they fill; and it is necessary for the public that it may quietly and securely enjoy the great modern boon of electric light and power. There may be and there is a question where this power of inspection and approval shall reside; with insurance, with electricians or with the public. As the greatest disaster, in case of dangerous defects, falls upon the insurance interests, as they are never quit of the risk, while the contractor is discharged of liability on payment of his bills, and as the absence of the stimulus of direct personal interest tends to make the public official inspection superficial, the duty seems to have been wisely assumed by the insurance interest. It has most at stake. It would probably inspect on its own behalf in any case."

In closing his paper of September, 1892, before the Association of the Northwest (to which I have elsewhere referred), Mr. C. C. Haskins makes the following pertinent statements regarding the necessity of rigid inspection generally and the value of "The National Code" as a guide for the inspector:

"This examination is still far from perfection. The underwriters should join hands and purposes throughout the land, from Bedloe's Island to the Golden Gate, and from New Brunswick to the mouth of the Rio Grande, and demand a proper installation, or refuse a risk on property wherever the hum or the light of electricity is known."

"I have before suggested and I now repeat, that the underwriter and fire department should work together for the general good. In every district

there should be within easy reach some competent person to whom the electrical inspection of an installation might be confided. It makes a wonderful difference when a plant is in prospect whether an inspection is to follow the installation or not. Without mentioning names or locality, I may say that I know of a case in a town where there was no inspector, and two plants were erected by the same constructors. The contract for one of these called for an inspection by an electrical expert; the other did not. The first was passed high and dry, with many complimentary remarks. The parties owning the second plant, accidentally learning that an inspector was present, pressed him to go over their plant. The result was that the second plant was utterly condemned, and the wires had to be removed from the building."

"The National Code, adopted by the National Electro Insurance Bureau, in August of 1891, forms an excellent guide for your inspectors. Armed with this, taking one section at a time, and going through a plant or installation with this Code as a basis for criticism, an inspector should be able to detect the faults of construction, and demand their correction where there is no regular electrical inspector. He will find an occasional stumbling-block, but I believe much good can be accomplished in the out-lying districts in this way. The day is not far distant when every union and association of underwriters will have competent electrical ability to guard its interests."

It seems probable that valuable suggestions might be obtained from the history and work of an organization which has done a great deal for the education of electric light engineers and insurance inspectors in the New England states. This was known as the "New England Electric Exchange" and resulted from a conference of electric light and insurance men March 27th, 1888. In its issue of April 12, 1888, Modern Light and Heat, published in Boston, noted the completion of the new organization, and in an editorial on page 407 of that issue, stated its objects in the following words:

"The New England Electric Exchange is primarily a place where practical men actually manufacturing or commercially operating electric light apparatus can meet, with the knowledge that the membership is restricted to men, who like themselves, are either making or commercially using electric light or power apparatus. It is not a place for the presenting of elegantly prepared scientific theses, or interesting biographical memoirs, or for profitable technical discussions, but it is a place where practical men can interchange ideas as to methods of greater safety in the installation of electric light and power apparatus of all kinds, improved methods of inside and outside wiring, the recital of personal experience as to peculiar and abnormal requirements of installation, which may come up from time to time, and which may be of general interest, and also it is a place where the conflicting interests of various electrical companies may be discussed and amicably adjusted. It is also a place where the once opposed but now harmonious interests of electric light people and the insurance companies can be still farther affiliated."

THE PROPER SCOPE OF INSURANCE RULES.

In the development of a new art so useful as that of electrical distribution it should not be thought strange that incongruities should exist,

especially where the growth has been so unprecedented as in this case. And it would be somewhat ludicrous to witness the attitude of the insurance fraternity during the past ten years in their attempt to teach the constructors of electric plants how they should do their work, were it not for the fact that the two or three insurance representatives who formulated the early rules were educated by the men most skilled in electric practice, and were compelled, that they might conscientiously consent to the writing of policies on thousands of buildings wired within an incredibly short space of time, to do missionary work from town to town, until they know far better than any electrical engineer of ordinary experience, what must be done as well as what must not be done.

But with the settling down of the work to well recognized lines, the underwriters will gradually gather a shorter and shorter code, until it will cease to be a manual of instructions to wiremen and become a statute book of what must not be done. This is the spirit in which other hazards have been treated.

At one time the insurance fraternity were obliged to take up the subject of coal oil, and found that burning oils used in New York City and elsewhere were dangerous. After making tests they determined on a fire test oil which would not flash below a given temperature. They secured a simple apparatus and enforced an inspection to determine when the oil was at a proper standard. It might be of widely varying specific gravity, but it must not fall below a certain flashing point.

The gas business has ever been treated in exactly this way by insurance men. In 1870 gasoline was used to enrich illuminating gas. It was contained within a sheet iron or tin vessel. It would leak, do what they would, and explosions seemed likely to become common. The attention of the underwriters was called to it. They did not profess to be competent to decide whether it was inherently dangerous, but they secured a good chemist who determined that the thing was an absolute hazard, and they prohibited it under penalty of cancellation of policies.

It was likewise found that where short gas fixtures were used in stores the ceilings caught fire; that where swinging brackets were allowed in hotels, drapery and particularly lace curtains were frequently ignited. They simply said, "You shall not use them, under penalty of forfeiture of your policy."

It is about six years ago that the good sense of applying the same methods to the electrical business was pointed out by Mr. S. E. Barton, chairman of the Electric Light committee of the New England Insurance Exchange, who was then one of the most active and useful representatives of the underwriters who has ever come into close contact with electrical people. He said in an official report:

"In the arrangement of our rules we were largely aided by the experience and information of our present inspector and some of the leading electric light people; and we have reason to believe that our rules have been a source of education to some engaged in the electric lighting business, perhaps to the detriment of the more scientific pioneers. Indeed, were we again to begin at the beginning, with our present knowledge, we think we would be inclined, in justice to all concerned, to issue rules setting forth

those practices that we would not permit, rather than stating in such complete detail what should be done."

The rules which can be laid down as fundamental in all electric light and power work as effecting fire risks are not so numerous but what any insurance inspector can acquire them in a short time. He is no longer called upon to act as a missionary to the benighted. If he consents to do this he neglects the primal object of his position. In other words the insurance inspector need not and should not be an electrical engineer. If a case arises where the application of the rules is not plain, it becomes his duty to refer the matter to the authority from which the rules have emanated, and this authority should be legislative in its function. Thus the principal difficulty which has been quoted in the way of a cheap and efficient insurance inspection would be in a large measure wiped out. If the underwriters were to require in all their inspectors and adjusters such a knowledge of the general subject as would qualify them to apply to a few plainly written negations, the duties of this ultimate electrical authority would not only be greatly lightened, but the service would be far better performed. It has been claimed in opposition to this view of the case, that the conditions which arise in the application of electric lighting are so varied and the distinctions which must be made are many times so fine, that it requires a technical education to make these applications and to pass judgment regarding these distinctions. Without doubt the ramifications of the detail of laws of nations are exceedingly intricate, but they may all be summed up in the Ten Commandments, and these commandments have been written in words so plain and so brief that there can be no excuse for a human being with sane mind failing to understand them sufficiently to obey them, or for his having so poor a memory that he is likely to forget them.

There seems to be no reason why the present "National Code," which has been prepared with this idea in mind, may not as the time goes on, be boiled down to a series of insurance commandments which can be accepted as rules of practice by every board or association of underwriters in the country, as rules of practice each of which shall begin, as do those of the decalogue delivered to Moses, "Thou shalt not."

THE REAL RELATIVE HAZARD.

I have in this paper dealt, hastily and imperfectly, with the various possibilities of fire hazard in the use of electric light and power circuits, because in order to realize how little difficulty has actually arisen, we must appreciate how great difficulties might in the nature of things arise, but for the exercise of intelligent care in construction and inspection. We cannot appreciate the freedom which we enjoy from the terrible results of boiler explosions until we understand what may happen in case of such an accident. And so, while laying bare such facts as these for your full information, I feel that our insurance friends are only confirming the good opinion they have for years been cultivating regarding electrical engineers as the result of our efforts to give the world better light, more light, cheaper light, and better and more economical motive power, quicker transportation and a new industry employing immense capital and whole communities of skilled mechanics.

A careful analysis of the situation shows that in spite of the possibilities I have discussed and illustrated, in spite of the tremendous energy often used in these modern electrical systems, in spite of the rapidity with which a new art has developed within fifteen years from a few germs to absolutely indispensable adjuncts of 19th century progress, in spite of the thousands who have necessarily been trained to the handling of a newly harnessed energy, the number of fires chargeable to its escape from practical control has in the United States at least, been phenomenally small. In response to requests addressed to the fire departments of the 165 cities of this country which have 20,000 inhabitants and upwards, for information regarding the number of fires, causes, and amount of damages sustained, during the municipal fiscal year most nearly conforming to the calendar year 1891, replies were received from 82, containing interesting and important facts. In 75 cities there were 18,118 fires from all causes, of which 202 were from electric lighting circuits, and 23 from power circuits, making 225 fires from electricity, or 1 2-10 per cent. of the whole number. In 59 cities there was a total loss of $21,357,539.95, of which the amounts chargeable to lighting circuits was $166,607.15, and that due to power circuits $50,292.60, making $216,899.75 or almost exactly 1 per cent. of the total losses. There are so many interesting items of information in these reports that I here quote (complete) a pamphlet recently published, which embodies them.

FIRES CAUSED BY ELECTRIC CURRENTS.

The following interesting exhibit of the number of fires caused by electric currents, and the losses from such fires, in certain cities in the United States, as compared with the total number of fires from all causes, and the resulting losses in such cities, was compiled by the statistical department of the General Electric company from reports made to that department by the chief engineer of the fire department of each city represented.

A request was addressed to the fire department of each city of 20,000 inhabitants and upwards for information covering the following points, for the municipal fiscal year most nearly conforming to the calendar year 1891:

Total number of fires from all causes.
Total damage caused by same.
Total number of these fires which may be directly attributed to electric lighting circuits.
Total damage caused by same.
Total number of fires attributed to electric circuits of other nature.
Total damage caused by same.

Out of the 165 cities coming within the scope of this inquiry, replies were received from 82, all of which are included in the tables herewith:

Table I. Shows the total number of fires in each city, and the number of such fires caused by electric currents divided as to lighting and power circuits respectively, and the total of both.

Table II. Compares the losses from fires caused by each class of electric circuits, with the losses resulting from fires due to all causes, in cities which reported in detail.

Table III. Embraces cities which reported fires caused by both lighting and power circuits, but gave the amount of losses from fires caused by lighting circuits only, the losses sustained by reason of fires from power circuits being set down as "nominal," "slight," etc.

Table IV. Presents the facts as to fire losses from power circuits only, similarly to Table III; the losses by fires from lighting circuits being reported in general terms as in the case of power circuits in Table III.

Table V. Gives the several items of reports which were so deficient in details as to entirely exclude them from the preceding tables.

The separation of fires caused by lighting circuits from those caused by power circuits is not entirely accurate, owing to the difficulty of obtaining the information necessary to an exact division of fires, as between the two classes.

Table I.—Number of Fires.

Name of City.	From all Causes.	From Electric Currents. Lighting Circuits.	Power Circuits.	Total.
Akron, O.	96		2	2
Allentown, Pa.	51			
Auburn, N. Y.	54		2	2
Baltimore, Md.	676	5	1	6
Binghampton, N. Y.	87			
Boston, Mass.	1,230	21	5	26
Central Falls, R. I.	32			
Chelsea, Mass.	83			
Chester, Pa.	45			
Cleveland, O.	982	16		16
Cohoes, N. Y.	41			
Council Bluffs, Ia.	74			
Covington, Ky.	106			
Dallas, Tex.	250	1		1
Davenport, Ia.	67	2		2
Dayton, O.	270			
Des Moines, Ia.	152	5		5
Detroit, Mich.	590	9		9
Duluth, Minn.	83			
Elmira, N. Y.	90			
Erie, Pa.	90			
Fitchburg, Mass.	45			
Fort Worth, Tex.	174		1	1
Grand Rapids, Mich.	264	5	1	6
Houston, Tex.	119	5	1	6
Jackson, Mich.	107		1	1
Johnstown, Pa.	17			
Kansas City, Kan.	154	6		6
Kansas City, Mo.	560	3		3
La Crosse, Wis.	79			
Lancaster, Pa.	60			
Lawrence, Mass.	87			
Lewiston, Me.	37			
Little Rock, Ark.	52			
Lynn, Mass.	145		1	1
Malden, Mass.	63			
Manchester, N. H.	71			
Memphis, Tenn.	275	2		2
Meriden, Ct.	48			
Minneapolis, Minn.	682	9	2	11
Nashville, Tenn.	117	2	3	5
Newburgh, N. Y.	1			
New Haven, Ct.	240	2		2
Newton, Mass.	86			
New York City, N. Y.	3,938	58	1	59
Norfolk, Va.	22			
Oshkosh, Wis.	1			
Paterson, N. J.	200	5		5
Pawtucket, R. I.	69			
Petersburg, Va.	37			
Philadelphia, Pa.	1,360	10		10
Quincy, Ill.	96	1		1
Reading, Pa.	57			
Rockford, Ill.	112	5		5
Sacramento, Cal.	80			
Salt Lake City, Utah.	115	2		2
Savannah, Ga.	196			
Scranton, Pa.	161	3		3
Seattle, Wash.	136			
Sioux City, Ia.	113			
South Bend, Ind.	42	1		1
Springfield, Ill.	96	2	1	3
Springfield, O.	86	2	1	3
St. Louis, Mo.	1,358	7		7
Tacoma, Wash.	120	4		4
Taunton, Mass.	66			
Topeka, Kan.	148	1		1
Troy, N. Y.	146			
Washington, D. C.	400	5		5
Wheeling, W. Va.	59	2		2
Williamsport, Pa.	54			
Wilmington, N. C.	69			
Woonsocket, R. I.	1			
Yonkers, N. Y.	55			
Youngstown, O.	93	1		1
Total	18,118	202	23	225

TABLE II.—Losses from fires caused by lighting and power circuits, respectively, compared with losses from fires due to all causes, in cities which have reported in detail.

NAME OF CITY.	TOTAL LOSSES FROM ALL FIRES.	LOSSES FROM FIRES CAUSED BY ELECTRIC CURRENTS.		
		Lighting Circuits.	Power Circuits.	TOTAL.
Akron, O.	$ 26,147.18		$ 752.60	$ 752.60
Allentown, Pa.	44,074.45			
Auburn, N. Y.	38,580.00		250.00	250.00
Baltimore, Md.	650,009.73	$ 350.00	25.00	375.00
Binghampton, N. Y.	48,395.93			
Boston, Mass.	1,629,413.00	95,200.00	15.00	95,215.00
Central Falls, R. I.	7,756.00			
Chelsea, Mass.	32,543.69			
Chester, Pa.	5,440.00			
Cleveland, O.	1,076,260.00	90.00		90.00
Cohoes, N. Y.	16,814.00			
Council Bluffs, Ia.	35,000.00			
Covington, Ky.	27,760.00			
Dallas, Tex.	883,899.63	25.00		25.00
Dayton, O.	21,372.39			
Detroit, Mich.	630,976.00	932.00		932.00
Duluth, Minn.	147,155.00			
Elmira, N. Y.	130,947.52			
Erie, Pa.	51,015.00			
Fitchburg, Mass.	20,276.25			
Jackson, Mich.	53,282.96		250.00	250.00
Johnstown, Pa.	63,200.00			
Kansas City, Kan.	48,985.00	820.00		820.00
Kansas City, Mo.	340,588.50	35.00		35.00
Lancaster, Pa.	125,000.00			
Lawrence, Mass.	12,578.26			
Lewiston, Me.	9,761.06			
Lynn, Mass.	54,963.64		3,000.00	3,000.00
Malden, Mass.	11,796.85			
Manchester, N. H.	59,542.63			
Memphis, Tenn.	370,145.70	987.00		987.00
Meriden, Ct.	25,184.00			
Newburgh, N. Y.	250.00			
New Haven, Ct.	73,254.08	37.55		37.55
Newton, Mass.	10,000.00			
New York, N. Y.	6,959,650.00	24,116.00	46,000.00	70,116.00
Paterson, N. J.	292,278.00	220.00		220.00
Pawtucket, R. I.	75,863.95			
Petersburg, Va.	26,985.59			
Philadelphia, Pa.	2,657,235.00	2,617.00		2,617.00
Reading, Pa.	150,000.00			
Rockford, Ill.	87,785.02	37,637.50		37,637.50
Sacramento, Cal.	140,260.00			
Salt Lake City, Utah.	95,820.27	20.00		20.00
Savannah, Ga.	345,265.00			
Scranton, Pa.	272,217.69	25.00		25.00
Seattle, Wash.	124,872.00			
Sioux City, Ia.	149,367.31			
St. Louis, Mo.	2,571,255.00	840.00		840.00
Taunton, Mass.	21,765.54			
Topeka, Kan.	76,330.89	1,790.10		1,790.10
Troy, N. Y.	89,329.24			
Washington, D. C.	162,086.00	800.00		800.00
Wheeling, W. Va.	47,000.00	50.00		50.00
Williamsport, Pa.	82,000.00			
Wilmington, N. C.	22,500.00			
Woonsocket, R. I.	5.00			
Yonkers, N. Y.	40,000.00			
Youngstown, O.	85,300.00	15.00		15.00
Total	$21,357,539.95	$166,607.15	$50,292.60	$216,899.75

TABLE III.—Losses from fires caused by lighting circuits, in cities not reporting the amount of losses from fires caused by power circuits.

NAME OF CITY.	FROM ALL CAUSES.		FIRES CAUSED BY ELECTRIC CURRENTS.			
			Lighting Circuits.		Power Circuits.	
	No.	Loss.	No.	Loss.	No.	Loss.
Minneapolis, Minn. . .	682	$1,156,069	9	$64,106.30	2	Not given.
Springfield, O. . . .	86	23,000	2	3,800.00	1	Slight.

TABLE IV.—Losses from fires caused by power circuits, in cities not reporting the amount of losses from fires caused by lighting circuits.

NAME OF CITY.	FROM ALL CAUSES.		FIRES CAUSED BY ELECTRIC CURRENTS.			
			Lighting Circuits.		Power Circuits.	
	No.	Loss.	No.	Loss.	No.	Loss.
Grand Rapids, Mich. . .	264	$14,655.71	5	Not Given.	1	$4,000.00
Springfield, Ill. . . .	96	14,235.25	2	No Claim.	1	3,000.00

TABLE V.—Reports which were deficient in details and omitted from either of the preceding tables.

NAME OF CITY.	FROM ALL CAUSES.		FIRES CAUSED BY ELECTRIC CURRENTS.			
			Lighting Circuits.		Power Circuits.	
	No.	Loss.	No.	Loss.	No.	Loss.
*Burlington, Ia. . . .		Not Given.		None.		
†Davenport, Ia. . . .	67	$31,285.00	2	Nominal.		
†Des Moines, Ia. . . .	152	Not Given.	5	$125.00		
†Fort Worth, Tex. . . .	174	" "			1	Not Given.
†Houston, Tex. . . .	119	" "	5	200.00	1	$10.00
†La Crosse, Wis. . . .	79	" "		Not Given.		Not Given.
*Lincoln, Neb. . . .		" "				
†Little Rock, Ark. . . .	52	" "		None.		None.
†Nashville, Tenn. . . .	117	328,806.45	2	Not Given.	3	Not Given.
†Norfolk, Va. . . .	22	Not Given.				
†Oshkosh, Wis. . . .		" "	1	None.		None.
*Pueblo, Col. . . .		" "		1,065.00		100.00
†Quincy, Ill. . . .	96	22,038.00	1	Not Given.		None.
*Salem, Mass. . . .		Not Given.		None.		"
†South Bend, Ind. . . .	42	4,873.74	1	Nominal.		
*Syracuse, N. Y. . . .		Not Given.	1	Not Given.		
†Tacoma, Wash . . .	120	29,704.36	4	Nominal.		None.
*Wilkesbarre, Pa. . . .		Not Given.		None.		
*Wilmington, Del. . . .	101	" "		22,000.00		15,000.00

*Not included in any of the preceding tables.
†Included in Table I, only.

EXPLANATORY NOTES.

The totals of Table I, show that lighting circuits caused 1.1 per cent. of all fires, and power circuits .13 per cent. Thus about one and a third per cent. of all the fires reported were directly attributed to electric currents, or about 1 fire out of 75. The percentages derived from the totals of Table II, are for lighting circuits .78 per cent., for power circuits .23 + per cent., and for all electric currents 1.02—per cent. of the total losses from fires caused thereby, as compared with total fire losses from all causes, or about $1.02 out of each $100.

One fire in Washington, D. C., (a gas tank struck by lightning, loss $10,000), reported as caused by the electric current, is omitted from these tables for obvious reasons.

The chief engineer of the Minneapolis fire department in his statement to this office gave the fire losses from lighting circuits at $169,644.30; his annual report, giving details respecting all fires, shows but $64,106.31 loss from fires, which are, in that report, attributed to electric currents. The greater part of this total may be charged to a single fire which caused a reported loss of $62,762.01, of which amount only $16,000 was on the premises where the fire originated; but owing to prevailing high winds the fire extended to neighboring frame structures, causing additional losses aggregating $46,762.01, all of which are included as losses from electricity.

EXTRACTS FROM REPORTS.

In this connection the subjoined extracts may be of interest; they are from letters accompanying the report from which the foregoing tables were compiled.

BALTIMORE, Md. "We do not consider them extra hazardous."

CHELSEA, Mass. "The danger from electric circuits is not as great as that from lightning."

CHESTER, Pa. "One of the safest plants . . . have not met with one fire from the current."

COHOES, N. Y. "There has not been any loss by fire and, I think, only one alarm caused by electricity since the . . . plant was installed."

COVINGTON, Ky. "I have never made any discoveries leading me to believe that electricity was in any manner the cause of any fires we have had."

DULUTH, Minn. "If wires are properly insulated, and carefully laid in buildings, I do not consider the risk great, not near as much as gasoline stoves."

FITCHBURG, Mass. "I have yet to wait for a fire that can be laid to electric currents of any description."

LANCASTER, Pa. "We have power circuits and electric lights all over the city, and cannot positively say of one fire that we can attribute it to the electric current."

LAWRENCE, Mass. "A few small fires in 1889 and 1890 caused by sparks from arc lights falling on light goods; since then I do not know of any."

NASHVILLE, Tenn. "Fires caused from electric circuits for the last ten or twelve years are hardly worth mentioning . . . we have as many electric circuits as any city of the same population."

NEWTON, Mass. "Cannot be considered an additional risk; it takes the place of oil, lamps and gas, dispenses with the use of matches, and in various ways prevents what were formerly prolific sources of accidental fires."

QUINCY, Ill. "As a fire risk it is not greater than any other system of lighting."

SPRINGFIELD, Ill. "Fire caused by an electric wire passing over and in contact with a leaky gas pipe."

It should be remembered that in the majority of the places named in the pamphlet which I have here reproduced entire, the stations were installed a number of years ago, and therefore not built in accordance with our modern ideas of durability and safety. In all large cities to-day, where the stations must of necessity be placed in thickly settled districts, the construction is as near fire-proof as anything can be. Masonry, stone and iron are used exclusively in the construction of the buildings; marble or tiling in the floors; all switchboards and instruments are mounted on marble or porcelain; all conductors in stations are also mounted on porcelain where they can be readily inspected and tested.

The foregoing and other statistics which are now available seem to show that there is nothing in the system of molecular transmission which we call electrical distribution which is inherently more dangerous than any other manifestation or method of transferring energy. In a paper read some time ago before the 20th Annual Meeting of the Fire Underwriters Association of the Northwest, by the well-known city inspector of Chicago, Clarke C. Haskins, the following paragraphs are pertinent in this connection:

"There is nothing in the form of power which is not dangerous if uncontrolled; nothing which is of benefit to mankind that has no danger in it, and the more beneficial to humanity the more circumspectly must it be handled, the more formidable must be the safeguards which surround it. The very heat of the sun is capable under certain circumstances of producing results fatal to the insurance business. Fire is one of the most valuable gifts of the Creator, but we have to constantly watch and fight to keep it under control."

"Electricity has come to stay, has shown itself an excellent servant. What is necessary to do is to prevent it from assuming the role of master. As a strong temperance man once said to me, 'What is wanted is not prohibition in the electric light business, but proper regulation—high license perhaps."

In the current number of "The Engineering Magazine" is a readable article on "Fire Risks in Electric Insulation," by Prof. F. A. C. Perrine, of Leland Stanford, Jr., University. On page 326, in attempting to extract a lesson from published statistics, the Professor gives the following suggestive summary based upon the reports which the laws of Massachusetts require,

from which, by the way, a vast amount of valuable information can be secured:

"From 1884 to 1889 the Massachusetts Insurance Commissioner's report shows that out of a total of 12,935 conflagrations in the state there have been 42 traced to electric wires,—scarcely half of one per cent. While it is yet more striking to notice that in 1887 there were 14 fires of an electrical origin, and in 1889 there were but 7 such fires in approximately the same total—but one more than in 1884—and this too in the face of most enormous extensions in electrical installations."

"In this connection it is interesting to note the other causes which are comparable to electricity in producing fires, and one is astonished by their trivialty:

Kerosene oil (breakage and explosion)	947
Careless use of matches	437
Curtains or goods exposed to gas or candle	224
Thawing water pipes	89
Clothes drying near stove	64
Fat boiling over	43
Cigar-stub in wooden spittoon	41
Smoking in bed	34

"And it is further noticeable that the most important of these causes are accompaniments of other methods of illumination."

"We believe that we may truly say therefore that an installation for the electric lighting of any building may be made perfectly safe as regards fire risks; using the word 'perfectly' in the human sense, for we know nothing connected with either science or our daily lives in which every form of possible accident may be absolutely guarded against."

Mr. Waterworth closes his recent St. Louis paper with several remarks that are full of meat:

"Undoubtedly from the insurance point of view the accumulation of many new and intense potencies, both of light and power and material—electricity among the rest—is forcing up the loss ratio of the country and slowly increasing the rates of insurance. There is none of us wise enough to put his finger on the amount, proportion or nature of this increase of the fire loss due to the universal use of electricity. Personally, I believe that in all its uses, when properly installed, it is an improvement over that which it has displaced."

* * * * * *

"I am not competent, even at this late day, to talk electric talk to you, nor would I attempt it in this presence if I were. I know I know much less about electricity than I knew I knew five years ago. Probably some of you have had the same experience."

* * * * * *

"But I can, from the height on which we now stand and with the prospect now within our ken, see enough to justify me in protesting against the paltry and narrow suggestion that, for any vain dream of temporary advantage or visionary profit, it would be wise or necessary that the great interests under consideration should adopt the law of self preservation as

the sole rule to govern their relations toward each other, and abandon that higher law of comity and mutual help under which they have hitherto lived and thrived together."

In commenting upon Mr. Waterworth's vigorous address, "The Electrical World" uses the following expressions, which are intelligent and timely, because they present forcibly the difficulty of applying the present plan of insurance supervision in localities where no central station exists, but where progressive citizens have installed isolated plants or wish their residences or business blocks wired in view of the probability of a supply of current in future (May 13, 1893, page 351):

"In a recent issue we had occasion to comment on the favorable views held toward electrical interests by insurance officials who had a knowledge of the electrical principles concerned."

* * * * * *

"The conclusion that inspection should be left to the insurance organizations seems to be wise. Any other system that can be imagined would appear to lack the two great essentials—that of the selection of inspectors for competency alone, and the spur to efficiency from the direct money interests at stake. It is greatly to be feared that the 'electrical expert' described is still in existence in too many localities, particularly where the visits of the insurance inspector are few and far between. It is difficult to see how he can be entirely eradicated, as an inspector cannot be resident in every town in which the electric light is used, and it is rather too much to require that work shall not be closed in until after one arrives, perhaps after considerable delay, and at a great expense besides, for a single inspection."

ELECTRICAL EDUCATION.

The busy insurance man cannot expect to become a skilled electrician. It is not necessary, but he should be as well informed regarding the general laws of electrical operation and the conditions under which electrical energy may be expected to do mischief, as he is in the case of gas. More than this, he should understand the distinctions which exist between the currents used by the great variety of devices with which the buildings he insures are in these days equipped. Many active insurance people seem to regard electricity as so radically different from the other forces with which they are called upon to deal, and so mysterious in its operation, that they hesitate to attack the subject. To such I hope the words of one well known to all the insurance fraternity may come with the force which their truth deserves. In a paper on "Recent Developments in the Electrical Transmission of Power, read before the New England Cotton Manufacturers' Association, April 26th, 1893, Mr. C. J. H. Woodbury says:

"I beg to deviate somewhat from my former papers on electrical subjects, and instead of confining myself entirely to practical results, give a little attention to some of the main principles involved, which will soon be as necessary a part of the knowledge of every manufacturer as the principles involved in water wheels and steam engines are at the present time."

Mr. Woodbury has had a long and varied experience in carefully watching electric light installations on behalf of the Boston Manufacturers' Mutual Fire Insurance Company, of which organization he has for years been vice-president. The work which was in the earliest stages of commercial electric lighting done by Hon. Edward Atkinson, has in later years devolved upon Mr. Woodbury in large measure. In a lecture delivered at Cornell University, November 6th, 1891, on "Fire Hazards from Electricity," Mr. Woodbury makes the following terse and comprehensive statement:

"Those whose familiarity with electrical lighting appliances is only that of to-day, with every element of the apparatus established in commercial affairs, can have but little appreciation of the condition of such matters a little over ten years ago. Everything was new, crude and undeveloped. The leading inventors were pursuing their investigations under great difficulty, not the least of which was the lack of trained assistants. Mechanics had much to learn in the construction of the apparatus; the proper manufacturing supplies were not in the market; and the steam engines especially designed for operating dynamos had not been made. The development of the whole business required invention, education and organization from one end to the other."

"Electric lighting then pertained to apparatus for the physical laboratory; now it is one of the great commercial features in the business world, reaching in all its applications in the United States to investments estimated by Lieut. Allen R. Foote, special agent U. S. Census, to be $232,202,850, out of a total of $552,202,852 invested in electrical enterprises and divided as follows: Telegraph companies, $125,000,000; telephone companies, $100,000,000; isolated lighting plants, $6,000,000; central station plants, $155,202,850; electric railways, $70,000,000; fire alarms and police patrol, $10,000,000; steamboat plants, $1,000,000; sundry industries, $10,000,000; manufacturers, $75,000,000."

"The introduction of electric lighting in this country was followed by numerous fires caused by this new method of illumination. After the disturbance incident to the first scare, careful investigations were made into the subject, the greatest result of which was the establishment of the opinion that the elements of excessive hazard were not necessarily inherent in such applications of electricity. In other words, such fires were to be classed as preventable fires within the limits of ordinary practical means; and on this basis the rules for electrical installations were first prepared, only to be followed by other rules, drawn up by various parties, to apply to new conditions for the use of electricity for the transmission of power and alternating currents, as well as to improvements in both arc and incandescent lighting."

"The electric lighting interests have always, and without exception, co-operated with the underwriters in these investigations, which indeed could not have reached to successful results had it not been for the indispensable services afforded by the skill of those engaged in this manufacture. The results have fully justified the means, for electricity is to-day the safest method of artificial illumination. This safety is not due to the absence of

possibilities of danger, but to the entirety with which these elements of danger may be held in control."

* * * * * *

"Because there is much that is strange, wonderful, and unprecedented in these applications of electricity, there has been a tendency on the part of the general public to expect too much from them, both by way of advantage and of mishap. In case of fire, the press frequently ascribe the results to electrical wires purely on presumption, without any evidence to establish the fact. Furthermore, in many instances such allegations are made when the known facts or weight of presumptive evidence indicate a contrary cause. It has been fully established by the experience of the past 12 years that a well installed electric lighting plant is the safest method of illumination."

The study which the subject of electrical agencies in commercial and domestic life imposes upon the intelligent insurance expert is likely to lead him to as great an admiration of the marvelous force which is being made to perform such an infinite diversity of good offices for civilized man, as has been shown by many specialists in other fields. He will, if he adopts this course, come to share the enthusiasm which the well-known English gas engineer, Denny Lane, Esq., happily expressed in his presidential address before the London Gas Institute, in the following sentiment:

"Electricity. A very Ariel among the physical forces. It has performed more marvels than ever that sprite wrought at the bidding of the enchanter's wand. In a fraction of a second it becomes a mechanical power or a chemical agent. It flashes into light, and ere a man hath power to cry, 'Behold!' it melts into music, and ere a man hath power to whisper, 'Listen!' it flits away, a swift and silent herald, to carry our messages from China to Peru. It is the master of the slave of all the world's agencies, commanding and obeying, creating or being created. Hotter than fire, a hundred thousand times swifter than sound—nay, sometimes far swifter than light itself—with inconceivable speed it races around our globe, yet in its headlong course keeping the compass steadfast to the pole; now shedding a bland light from crystal flowers like the jeweled lamps of the Eastern story; now with unerring fingers guiding by night and by day, in fog and in eclipse, the sailor across the pathless sea; and anon the messenger of death, striking as with an arrow and leaving of proud man nothing but a blackened corpse. Potent, manifold, even among the ever changing powers, it is the very Proteus of them all."